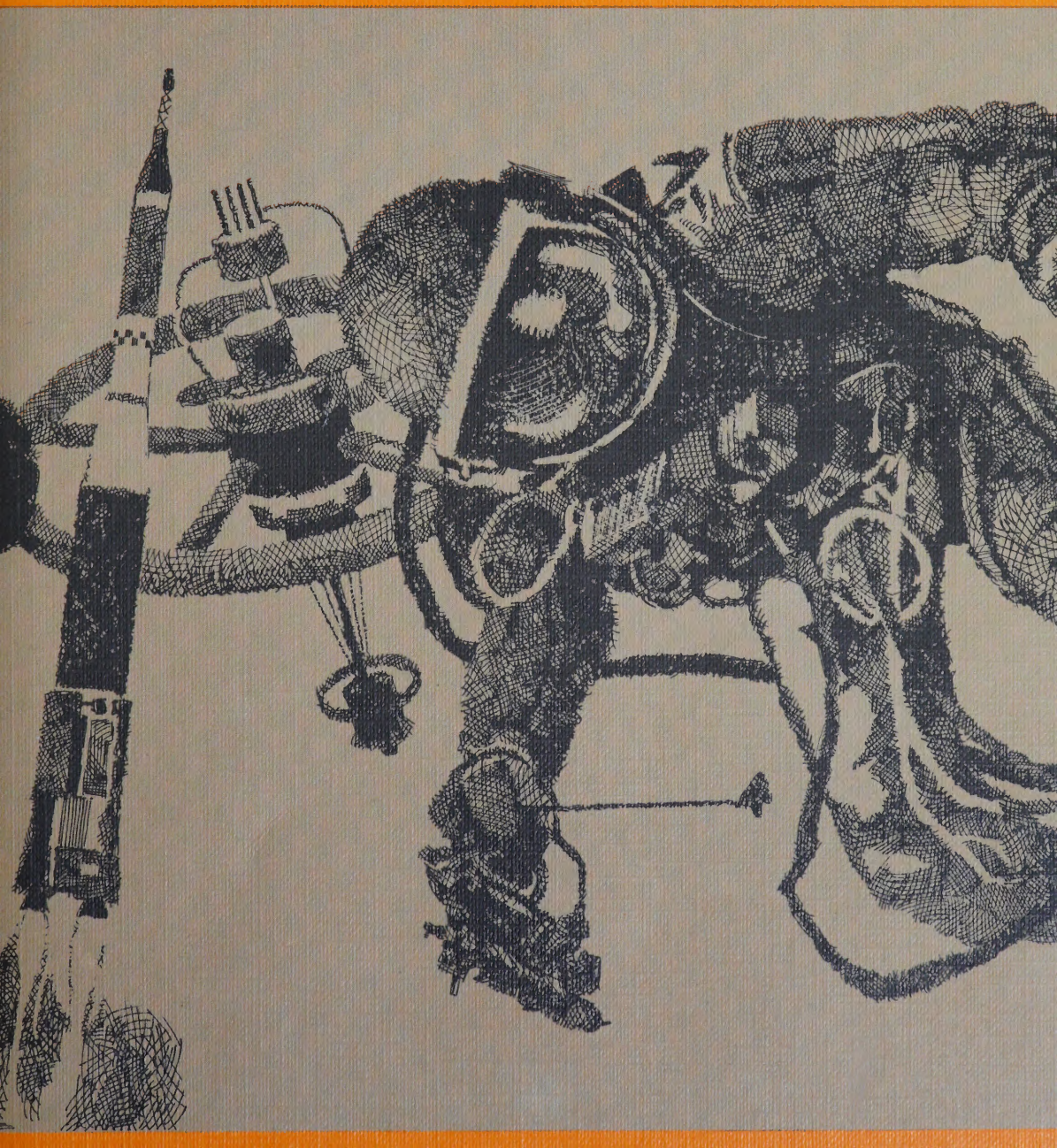
The Navigators

MAN IN HIS WORLD



The Navigators

James Forrester
Douglas M. Gray

Fitzhenry & Whiteside Limited
VANCOUVER WINNIPEG TORONTO MONTREAL

MAN IN HIS WORLD SERIES

James Forrester — Co-ordinating Editor

Nomadic Journey
Gifts of the Nile
Mexico Emerges
Eskimo — Journey Through Time
Grassland Safari
The Navigators
Indians of the Plains
China
Kings of Peru
Teacher's Guides

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Printed and bound in Canada

Photo Credits

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26/Golden Press
36/Hollis & Carter
61/Harper & Row
Library of Congress
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Charles Scribner's Sons
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Editor Robert Read
Artist Vlasta Van Kampen
Designer Hugh Michaelson Ltd.

Acknowledgments:
The section on Columbus' log is adapted from *The Journal of Christopher Columbus* translated by Cecil Jane, Bramhall House.

The New Ocean

Count Down Into Space:

December 21, 1968

The 363 foot high Saturn V rocket roared explosively. Flames, smoke and thunder all told of the enormous power – 7,632,500 pounds of thrust – that was being generated to launch the space vehicle for the lunar mission. Apollo 8 was on its way.

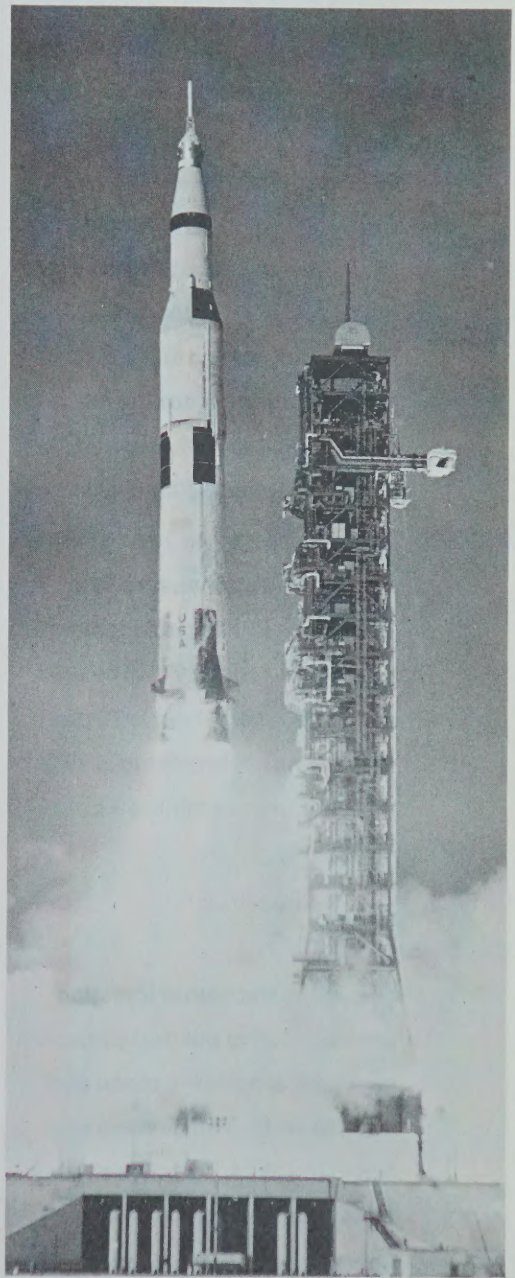
The Log of Apollo 8

00:00:00 Lift-off

00:00:32 "The clock is running."
"Roger, clock", responds Houston.
For the next eleven minutes, Apollo 8 climbs with ever-increasing speed. The astronauts watch their panel display: it has 24 instruments, 71 lights and 566 switches. The space commander keeps his hands on the controls, ready to take action, but the automatic control works smoothly.

00:00:50 "First stage separation."

00:07:00 "Second stage separation."
The spent stages have been dropped into the Atlantic Ocean.



00:11:25 "We have cutoff."

The powerful hydrogen engine of the third stage S-IVB has pushed the spacecraft to a speed of 17,428 miles an hour. Apollo goes into a nearly circular orbit, a little more than a hundred miles above earth.

The navigator makes his first sightings. He uses a scanning telescope and a sextant fitted into the side of the spacecraft.

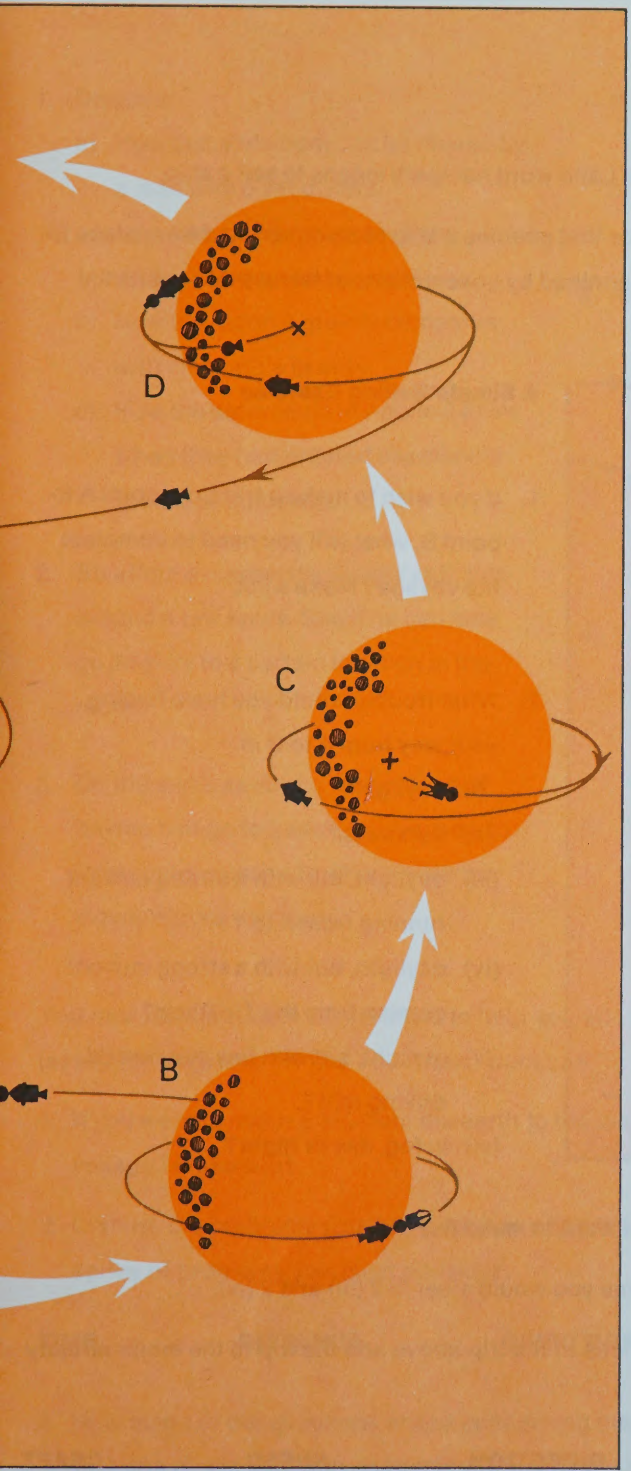
During the journey to the moon he will need to determine the *location* of the craft in space, the *direction* it is going, and its *speed*.

01:53.00 Cabin pressure has been holding at 5.2 pounds per square inch since launch. The cabin temperature is fairly cool, 62°F. The navigator's heart beat is 70 per minute and his breathing is 20 to 25 respirations a minute – both very good.

02:50:37 "Third stage fired."

02:55:42 "Cutoff."

This is the translunar injection burn needed to put the spacecraft on a path around the moon and back to earth. The men are now travelling at 24,226 miles an hour, faster than man has ever flown before.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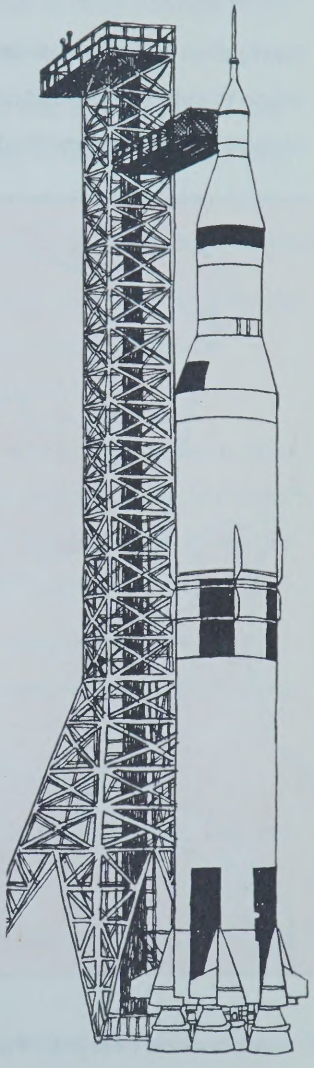
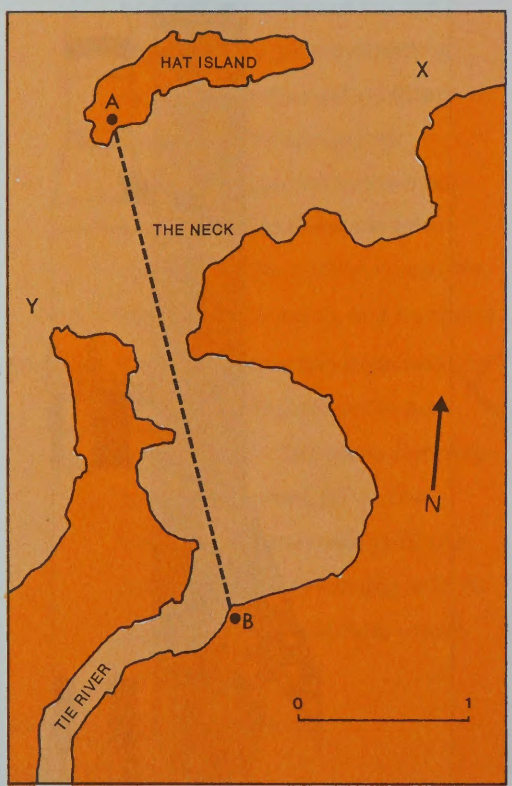


PROBLEMS OF NAVIGATION

DID YOU KNOW?

- The Latin word for ship is *navis.* • The Latin word *navigare* means to sail a ship.
- Navigation is thought of as the science that enables a ship to be conducted from place to place in safety, her position to be determined by observations of terrestrial or celestial objects, or by other methods.



A Simple Sailing Exercise

1. If you wish to make a trip from point A to point B, what will you need to complete the voyage? Make a list.

2. What trouble would you have finding your way from A to B in
   (i) daylight?
   (ii) darkness?
   (iii) daylight, but with a strong current running from X to Y?
   (iv) daylight, but with a strong current coming from the Tie River?
   (v) at night, but with low clouds and driving rain?
   (vi) in fog, day or night?

3. Give several reasons why you might want to make this trip.

4. Draw diagrams to illustrate the course you would steer in 2 (iii) and 2 (iv).

5. Write a note comparing the differences in the trip above and the trip to the moon already described. Use these headings:

TIME **DISTANCE** **DIRECTION** **SPEED** **CRAFT**

THINGS TO DO

1. Discover:
   a) How fast a rowboat can be moved by a man with a set of oars.
   How fast a 12-foot boat will go with a 75-horsepower motor.
   b) How the moon's gravity compares with the earth's gravity.
   c) How the astronauts in Apollo 8 knew when they had entered the moon's sphere of influence.

2. Blindfold a classmate. Gently spin him around a few times. See if he can now go *directly* to a certain location in the room.

3. Do the same as above, but instead of having him go to a spot, tell him now to intercept a classmate who is walking slowly across the room.

DID YOU KNOW?

1. a) The escape velocity from the earth is 25,200 miles per hour.
   b) The escape velocity from the moon is 5,330 miles per hour.

2. a) The moon was 218,700 miles from earth when Apollo 8 was launched.
   b) The moon was 240,500 miles from earth when Apollo 8 returned to earth.

3. At 38,900 miles from the moon, Apollo 8 entered the moon's sphere of influence (gravity).

4. In the three-day trip to the moon, only the navigator saw the moon and then only through his telescope. It was like being on the inside of a submarine.

5. Just before entering the moon's pull, Apollo 8's speed was only 2,223 miles an hour.

You now have a wealth of materials to help you answer the following questions. Use the (a) log (b) diagrams (c) Did You Know? sections (d) pictures.

1. If you were to make a trip from the earth to the moon, what would you need to complete the voyage? Make a list.

2. Discuss the problems you would have to solve in finding your way to the moon. Here is a series of problems you must consider.

TIME **DISTANCE** **DIRECTION** **SPEED** **CRAFT**

3. How many of the questions asked concerning the diagram, "A Simple Sailing Exercise", on page 6, are useful in examining the diagram on pages 4 and 5?

COMMUNICATIONS

T minus 2 hours 17 minutes

T minus 9 seconds
00:00:00

1030
1050
1105
1212
1245

LOG NUMBER 1

Spacecraft hatch closed
Command module ready
Ignition
Lift-off
Everything is GO – weather, range, crew, vehicle and tracking network.

LOG NUMBER 2

Standby engines
Half-astern both
Steer 030°
Revolutions 137
Deck clock (watch)
12 hours 29 minutes 50 seconds
Sextant altitude 26° 10′
Estimated position 20° 15′ N.
65° 03′ W.

1. The logs refer to two different oceans. Identify them.
2. Identify the "new" ocean.
3. How would you describe each ocean?
4. Which log refers to the new ocean and to the new language of communication?
5. Can you add more entries to each log? Try.
6. Start a log of your own that will illustrate the *new* language of space as it is used in this chapter. To do this use the words which refer to:

TIME **DISTANCE** **DIRECTION** **SPEED** **CRAFT**

7. Why is the language used to describe time, distance, direction, speed and the craft in log number 2 not good enough for us to use in log number 1?
8. Review the problems of navigation each ship must be prepared to face.
9. When Christopher Columbus sailed in 1492, could he assure his men where they were going? Did anyone on the 1492 voyage even dream of a "new world"? Were they able to talk to anyone "back home"? Did they know how far they had to go?

THINGS TO DO

1. Close your eyes. Open them in *exactly*
   2.4 seconds,
   34.0 seconds,
   51.0 seconds.
2. Take your pulse rate. How might this help you to do what is required above?
3. Think of other ways to tell time without using your eyes. Consider temperature, noise, winds, smells, lights, precipitation. Add to this list.
4. Construct a sandglass that will empty in *exactly* 2.4 seconds,
   51.0 seconds,
   one hour.
   (Now that you have tried to do all these things, answer the question, "Why was I asked to do them?")

DID YOU KNOW?

- Space-research centres use quartz-crystal clocks and atomic clocks.
- Atomic clocks can be so accurate that they lose only one second in 3000 years.
- Some atomic clocks cost more than half-a-million dollars.
- The electric current in an atomic clock flows thousands of times faster than in your electric clock at home or at school. (Why have all these things been mentioned?)

1. Ask as many questions as you can about Saturn V and Apollo 8 and about the first three hours of the flight. To help you do this, re-read pages 3 and 4 . Write down the questions.
2. Why did the astronauts want Houston to know, at 00:00:32, "the clock is running"?
3. In the diagram on page 6 , was a clock needed in order to go from A to B? Explain.
4. What kind of clock would be needed on Apollo 8? Why?
5. Tell why you think a special clock, tied into a computer, would be necessary to deal with travel at speeds of 24,000 miles an hour.
6. Would a sundial or a sandglass be of any use in space navigation? Explain.

THE LOG OF APOLLO 8 CONTINUES

09:24:00 "The power plant is providing us with heat, electricity and drinking water. I'm going to go to sleep now."

10:55:00 The service propulsion system (short form: S.P.S.) engine must be fired to bring about a mid-course correction.

11:00:00 The engine is fired for *exactly* 2.4 seconds which adds 25 feet per second or 17 miles an hour to Apollo's speed.

NOTE In Mission Control they are pleased to see that the console displays show normal pressure and temperatures in the spacecraft. They also show that the engine is working well.

13:26:00 "We are now 78,000 miles from earth, but our communications with you are excellent. Thanks for the newspaper that you've just read to us."

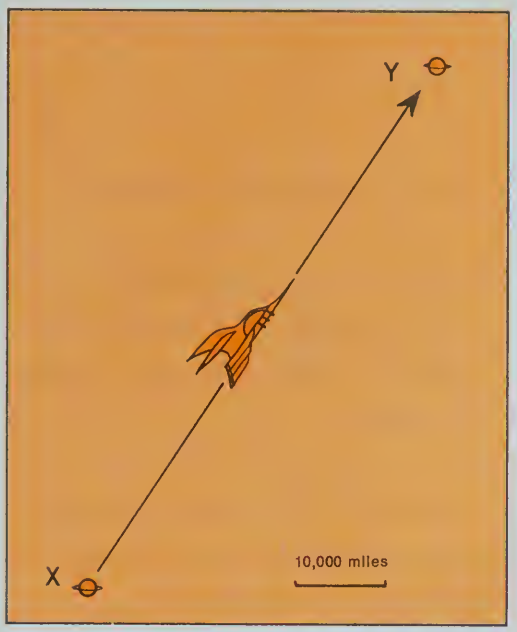
31:15:00 "I'll turn on the TV camera so you can watch me mix water into a bag of freeze-dried chocolate pudding."

Use the statements made by the astronaut and look at diagram on page 11 to complete columns A and B.

A	B
Ideas about power	*Ideas about living in space*

DID YOU KNOW?

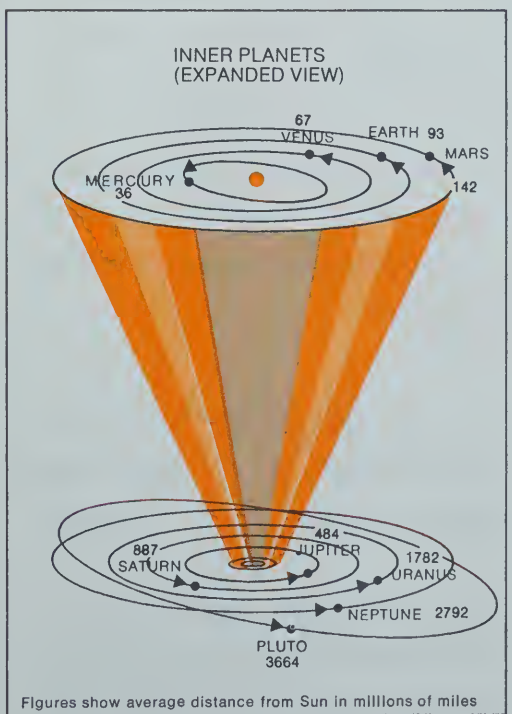
- There is a tape recorder on the spacecraft. It serves as the ship's log. The conversations of the crew are all recorded on this ship's log.
- The TV camera used on the spacecraft weighs only 4½ pounds.
- A computer tells the astronauts about their speed, their fuel supply, and how their engines are working.



PROBLEMS OF NAVIGATION

New, amazing speeds to handle

1. How fast would a spacecraft cover the distance between X and Y
   (a) at 5,000 miles an hour?
   (b) at 17,000 miles an hour?
   (c) at 24,000 miles an hour?
2. At 17,428 miles an hour, what would happen to the spacecraft if the S.P.S. engine burned *only one* second instead of exactly 2.4 seconds, the time needed to correct Apollo's course for the moon?
3. The burn took place at exactly 11 hours into the flight. What would have happened if the engine had fired at 10:58:00?
4. How do the astronauts know that they are travelling at 17,428 miles an hour?
5. Why do they want to know?
6. Why are these men going to the moon?

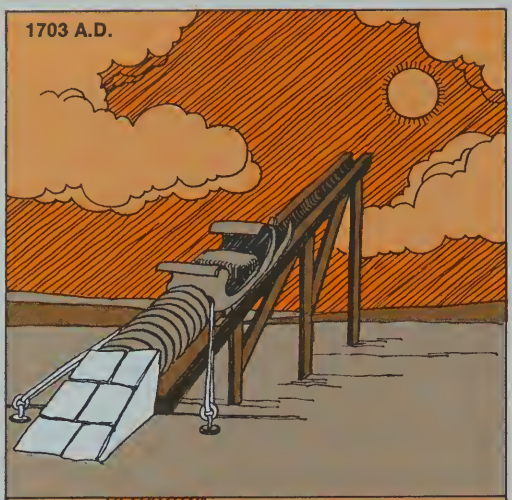


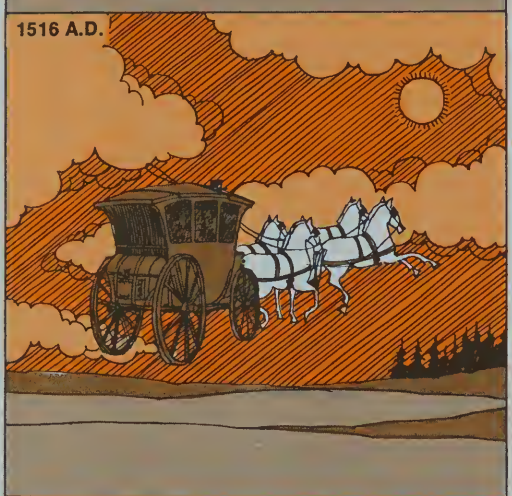
Figures show average distance from Sun in millions of miles

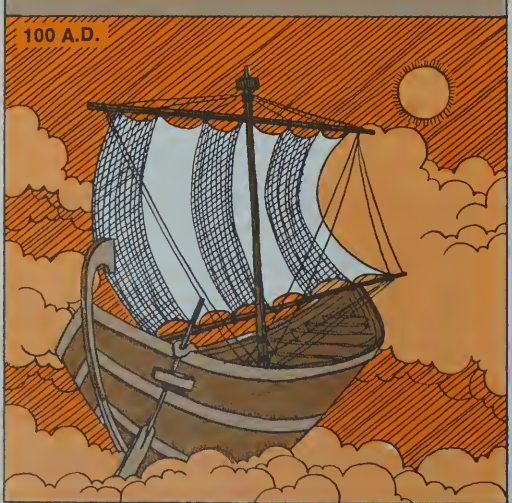
DID YOU KNOW?

- The Apollo 8 spacecraft re-entered the earth's atmosphere at 25,000 miles an hour.
- Saturn's five engines are able to send the spacecraft off at a speed of 17,400 miles an hour.
- The altitude of a heavenly body is the value of the angle between the body and the horizon.

1. How far would Apollo 8 have to travel to reach
   (a) the sun?
   (b) Mars?
   (c) the nearest star other than our sun?
   (d) the next galaxy?
2. How long would each trip take if Apollo 8 were to travel at 24,000 miles an hour?
3. What problems would have to be solved to keep the craft going at that speed?







A SHIP TO SAIL THE NEW OCEAN

1. Observe the dates on each drawing.

2. Explain how the time conditioned the creation of each picture and how each shows man's constant dream of reaching the moon.

3. Try to draw a picture of the vehicle you think will be going to the moon, from earth, in the year 3000 A.D.

4. With the knowledge that you now possess, consider why the methods shown in the pictures opposite are not suitable for going to the moon.

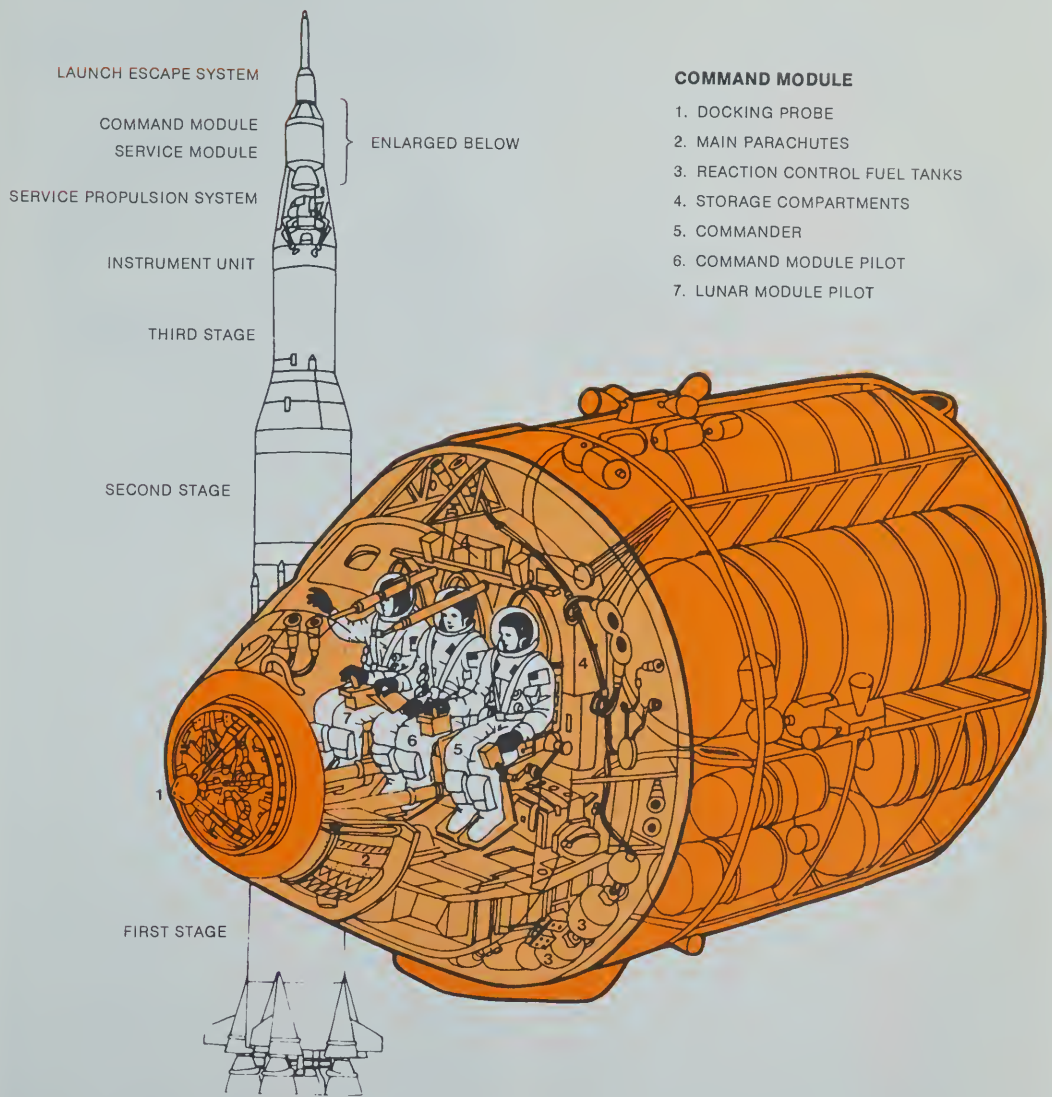
5. Write down as many ideas as you can about the problems you would have to solve if you were to take these vehicles to the moon.

6. Put your ideas into the proper column.

IDEAS ABOUT LIVING IN SPACE	IDEAS ABOUT POWER

7. For how long do you think man has expressed an interest in going to the moon?

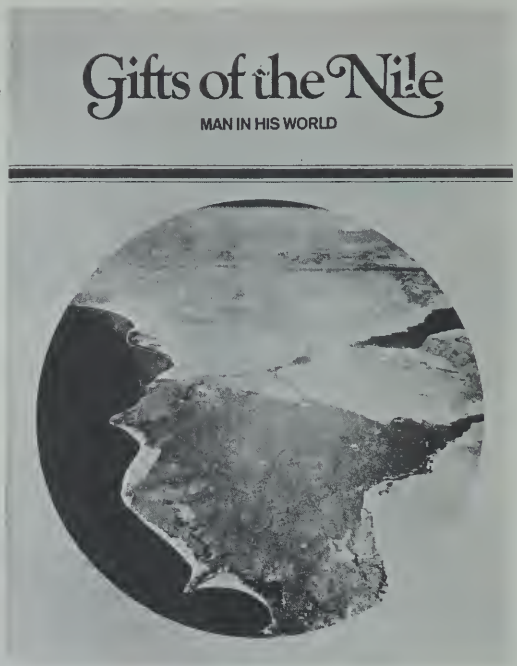
Apollo Spacecraft



DID YOU KNOW?

- The cost of Apollo 14, which carried man to the moon for the third time, was $400,000,000.
- The cost of the U.S. Man-In-Space programme to 1972 was over $25,000,000,000.

The River



Before reaching into the endless oceans of outer space, man had to conquer navigation problems on much smaller oceans, lakes and rivers. To trace his struggle to do so, let us return to the setting of *Gifts of the Nile.*

A Simple Little River Craft

We have learned about a great people who lived along the banks of a great river. These were the Egyptian people and the river was the Nile. There is truth in the ancient saying that Egypt's greatness was itself the "gift of the Nile". Of the many "gifts" offered by the river, the gift of a highway connecting and unifying all the people in a wide area is of major importance.

The people made good use of the gift. They learned to build rafts, reed boats and barges. They used these craft to conduct trade and so became rich and powerful. It can be fairly said that, without this river and man's skilful use of it, a great civilization would not have developed.

DID YOU KNOW?

- The earliest known record of ships comes from Egypt.
- Wood was scarce in Egypt.

THINGS TO DO

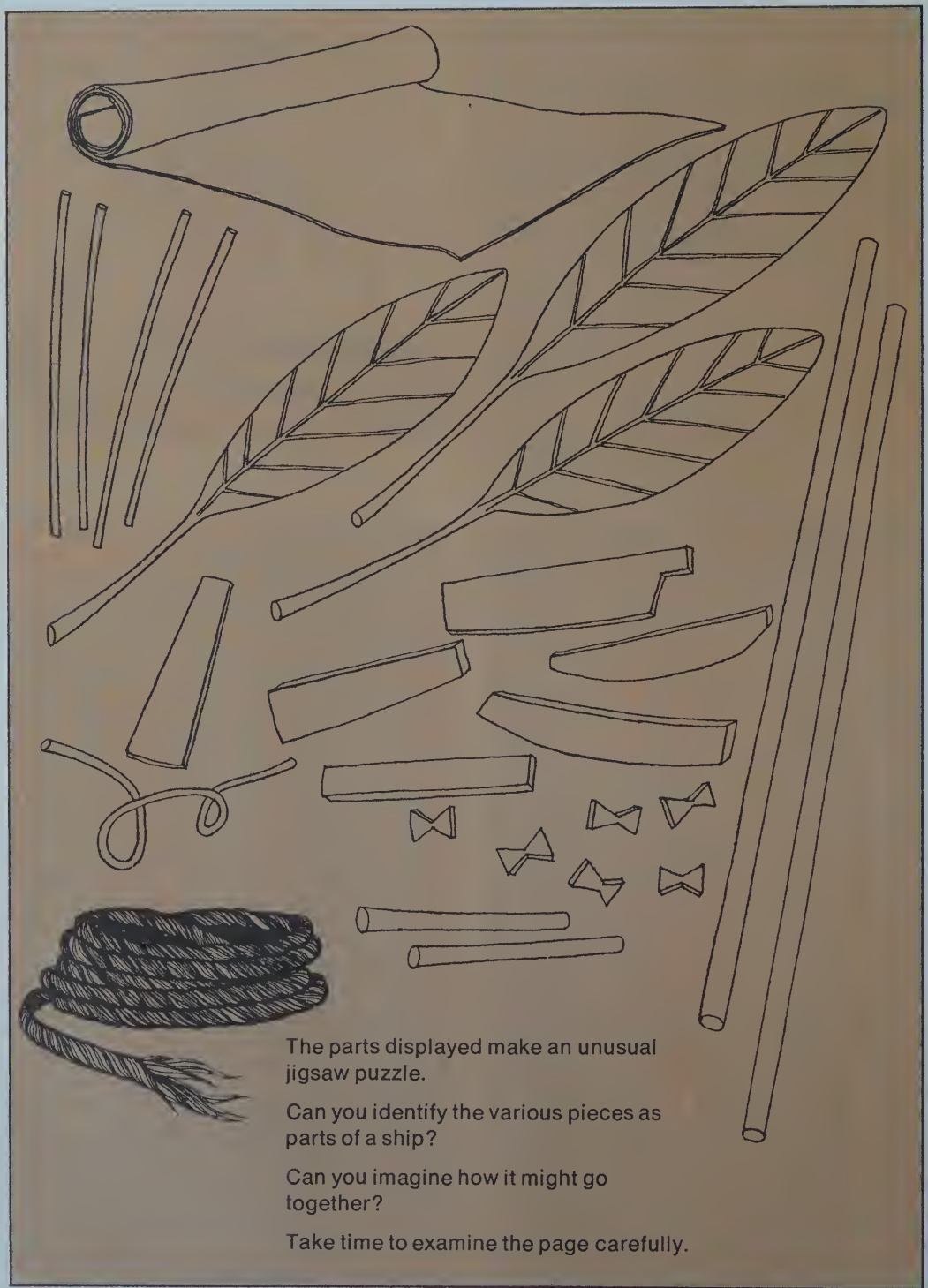
1. Open the Bible to Exodus Chapter 2 and read the first ten verses.
2. Discover what a boat builder in Egypt would do with an *adz.*

How man travels, the distance, speed and the reasons why he travels, are all very important. A discussion of each helps us to better understand his marvellous achievements. In the land of Egypt, the answers are found in a humble river craft, constructed of

pieces that are displayed on page 16 . You may well wonder how anything that would float could be put together from this strange mixture of bits and pieces. That the Egyptian could do so is a mark of his achievement.

KARNAK

LUXOR



The parts displayed make an unusual jigsaw puzzle.

Can you identify the various pieces as parts of a ship?

Can you imagine how it might go together?

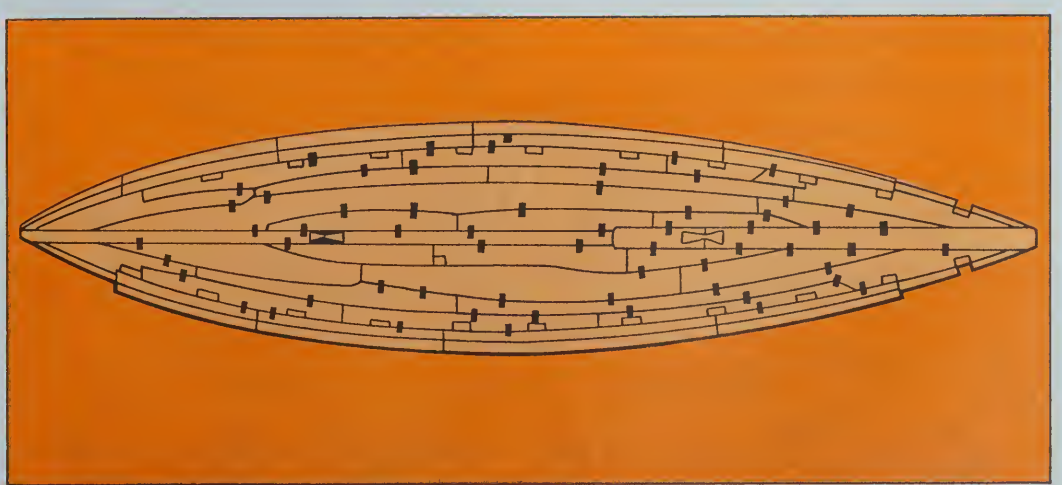
Take time to examine the page carefully.

A visitor to ancient Egypt, a man called Herodotus, tells us that pieces of plank made up the ship's hull and were about 41 inches in length. According to Herodotus, putting them together was similar to building with bricks. This seems a little hard to understand, but a carving found on the walls of a tomb suggests that Herodotus was not far wrong in his observations.

DID YOU KNOW?

- The Nile is the longest river in the world, twisting for 4,145 miles through jungle and desert.

Even better evidence has been recently found. In one of the tombs, searchers uncovered a full size funeral barge still in very good condition. They found that the hull was assembled from pieces of plank that had been painstakingly fitted and pegged together. These in turn were pegged to long poles running lengthwise. You can see this in the drawing of the ship's hull.

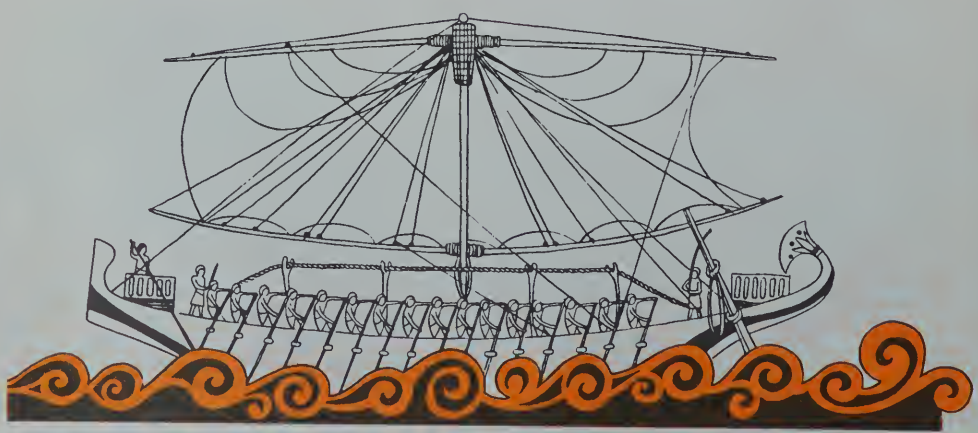


How can such a thing float? Will the water not pour through all the cracks? To prevent this, our ancient boat builders stuffed the cracks and joints with a kind of heavy paper called papyrus, adding to this gum and resin.

If this boat has no real frame, how does it hold its shape? As you can see in the picture, both the bow and the stern are lifted high out of the water and the sides of the hull also ride high. If you study the picture carefully, you can determine how the problem of holding bow and stern in position was solved, and, recalling the leather trusses or thongs, you can easily see how the ship's sides were held in position.

DID YOU KNOW?

- Early Egyptian boats had to be of *shallow-draft* to sail over all the sandbars in the Nile River.
- The Egyptian boat had no rudder and no keel.
- In Egypt, bundles of papyrus reeds, lashed together to form boats, were weak and sailed well only on calm water.



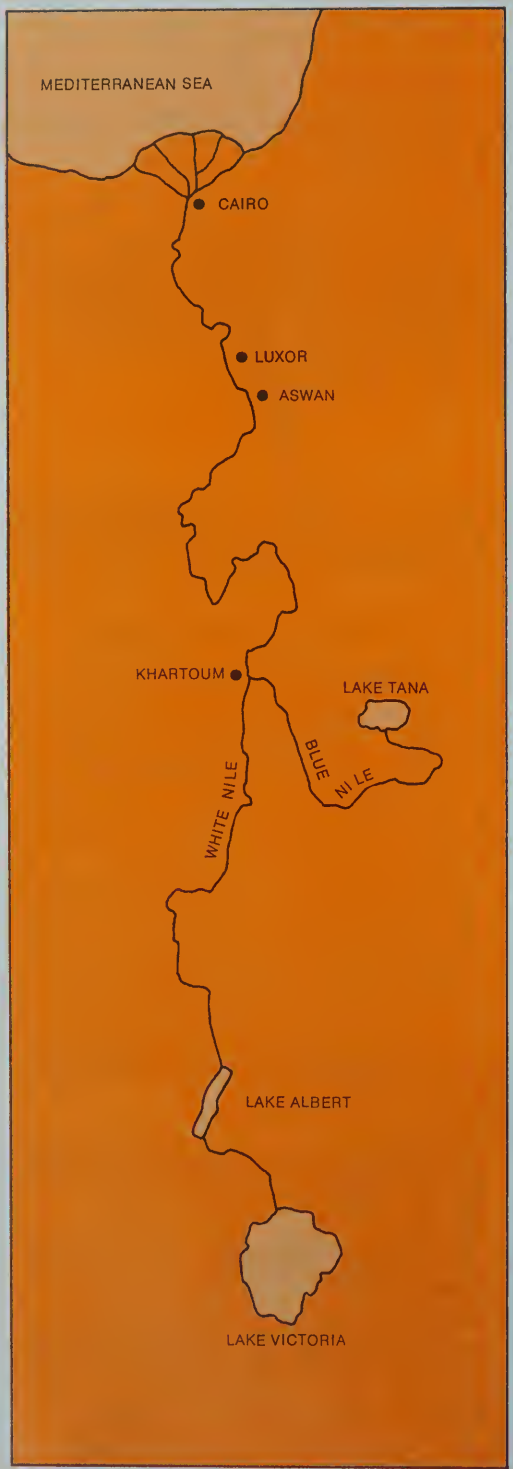
PAPYRUS: The Paper Reed

A greek scholar, Theophrastus, mentioned the variety of uses that the Egyptians made of papyrus. Since it grew in water, it provided an ideal material for boats. The umbrella or flower was used as decoration on the garlands for the gods; the thick and woody root was useful for making utensils and fuel for fires. The most useful part was the stem, which grew to a height of six feet. Its pith was a common source of food and could be eaten cooked or uncooked. The stem itself was used in making boats, caulking, mats, sails, cord, rope and, above all, paper, from which the plant received its name, "the paper reed".

In May 1970, Thor Heyerdahl sailed his papyrus reed craft the Ra II from Rafi, Morocco and landed at Bridgetown, across the ocean in the Barbados, 57 days later.

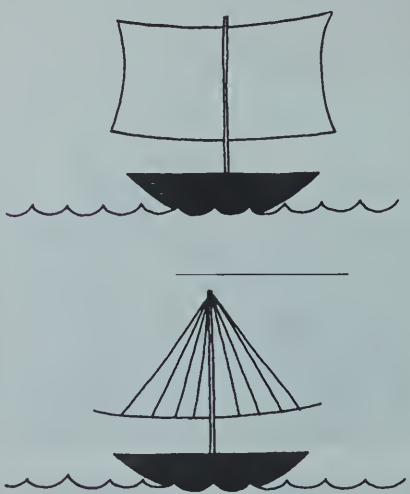
Here are some questions that are perhaps a bit more difficult.

1. What does this boat tell us about natural surroundings in which these people lived?
2. How can this boat help us to appreciate how advanced these people were?
3. Here is a recent picture of a river boat on the Nile. This should suggest several things to you about the Egyptian people. List them and comment on them.



4. The Nile River is noted for an absence of docks or similar facilities for loading and unloading boats. The Egyptians were an efficient people. Why did they not build such facilities?

5. In view of the problem suggested in the previous question, how would the high bow and stern be useful?



6. Here are two Egyptian symbols. The first means "going upstream" and the second "going downstream". How do these symbols suggest such directions?

7. An early river craft in Canada was the canoe. In many ways it was similar to the Egyptian river craft. Point out the features and purposes these two craft have in common.

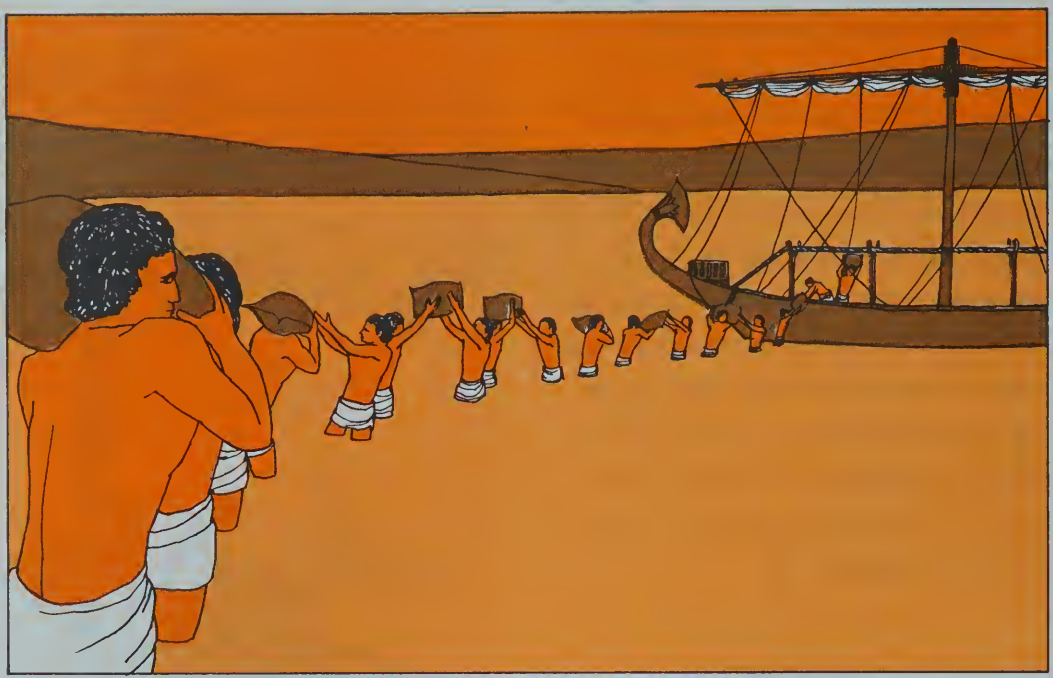
"I hope the picture painted of the Nile River boats has not upset you so much that you would refuse to travel in one. It's possible that you may not want to put yourself in the care of such a flimsy craft, held together by assorted pieces of wood, paper, string, and even a little gum. But let me assure you that we will all be perfectly safe – especially if we take time to offer the proper prayers and ritual to Sobek the crocodile god. All sailors seek the favour of Sobek and ask for his protection on any voyage. So let us ask Sobek to be kind."

DID YOU KNOW?

- 97 per cent of Egypt is uninhabitable.
- The desert of Egypt has fewer than 50,000 people, including the oasis-dwellers, but 27 million people are crowded together in the valley of the Nile in Egypt.
- The strip of black earth, which lies like a long snake between the yellow sands, is one of the "gifts of the Nile".

THINGS TO DO

Construct a small boat and experiment to discover the purpose of a keel and a rudder. Determine what draft has to do with a ship's *stability.*



If we turn far back in time, we will find ourselves standing on a mud flat of the river just below a small village. From the flat we see a group of villagers standing in a long line that extends from the shore out into the water until it reaches a small cargo vessel anchored offshore. The villagers are passing sacks of grain out to the boat. Since there are no docks, it is necessary for the pilot to keep the boat offshore, with the result that some of the loaders are standing in as much as two feet of water. The rhythm of their labour follows the beat of a song that they are chanting. The words sound something like this.

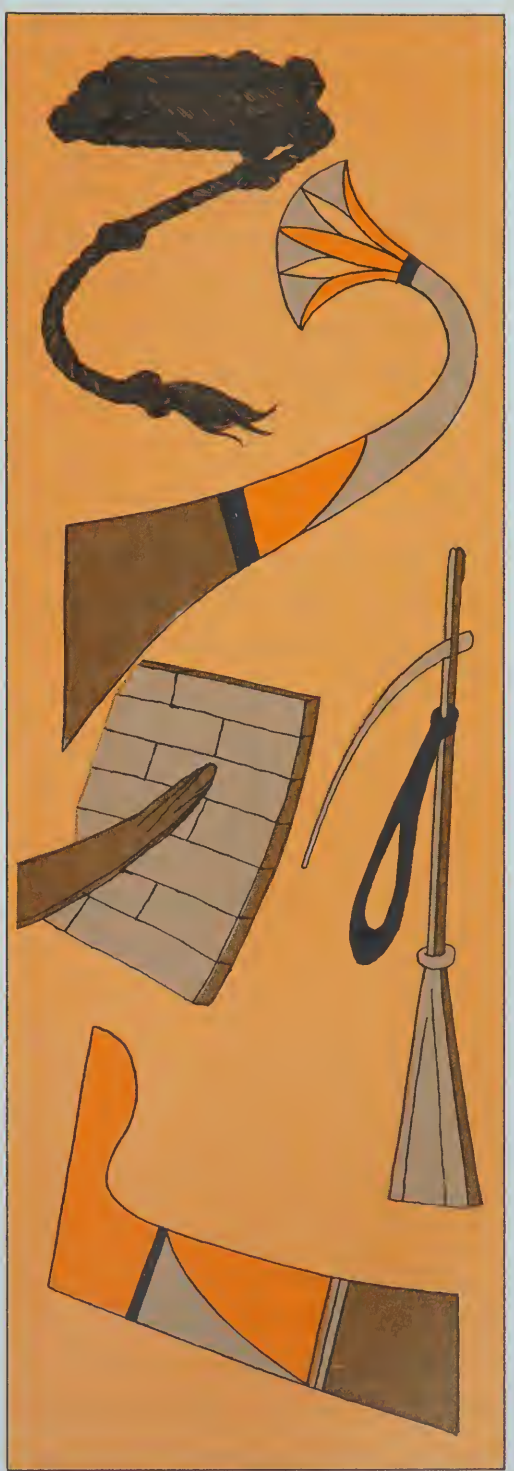
Are we going to spend the whole day carrying barley and wheat? The weather is fine; the barns are full to bursting. There are piles of grain to fill them. The boats are full and brimming over with barley. We are being told to work quickly. Do they think our hearts are of metal?

THINGS TO DO

Illustrate the following sentence:

At every bend of the Nile, shadufs measure the hours like seesaw pendulums, and sakias turn as deliberately as clock gears.

Our pilot instructs us to wade out and be lifted onto the ship. Our craft is only a small cargo vessel and after a while the loading is completed and the villagers return to their mud huts. The pilot stands in the bow and sings out an instruction to the crew. Six rowers nimbly scramble from the leather thwarts where they were squatting, climb up on the lower yardarm, and push into position a great sheet of sail made of patches of coarse linen. With a deft shove on his long pole, the pilot swings the bow around into the current of the river. In a high-pitched singing voice, he instructs a crewman standing near the stern to alter the angle of the sail. He does so with a vigorous pull on one of the halyards or ropes attached to the sail's boom. As it swings around, the sail flutters undecidedly, then suddenly fills out as it catches the north wind. The mast creaks under the strain and we can feel the movement of water beneath the craft as we turn upstream against the river's current.



With the craft now under way, the pilot takes his position in the bow where he swings in circles a rope to which a weight is attached. He casts the rope and weight into the water, well ahead of the bow. As the rope goes out, he counts the knots evenly spaced along it, singing out what he reckons to be the depth of water. Time after time he

carries out this procedure, for much of the river is shallow and the sand shoals are forever shifting. Occasionally his voice changes pitch — apparently signalling a sailor standing in the stern to rudder the boat one way or the other. This the sailor does by pulling hard on a long paddle tied to the stern so that the ship alters its course and avoids running aground.

DID YOU KNOW?

- The seasonal north winds, which blow regularly from May to October, helped to join the Greek and Egyptian worlds together.
- The invention of sailing gave people a great boost, because it reduced the muscular effort of rowing.
- A "north wind" is a wind "blowing *from* the north".

The procession of traffic moving downstream is never-ending. There are countless small craft of every description. Sails are furled as the current pulls the boats downstream. Some craft carry cattle, donkeys and goats; some carry slaves, others ivory. Occasionally, the fragrance of precious ointments and incense wafts across the water. A most unusual sight is a great log raft, laden with huge blocks of granite and limestone, moving slowly with the current.

A strange rhythmic drumming suddenly echoes across the water as a brightly coloured barge sweeps into view around a bend in the river. The sound comes from a gong, struck at an even tempo to set a pace for the rowers. Their oars flash in time to the quick beat. As the swift moving craft approaches, we see the pennant of the Grand Vizier fluttering from the masthead. This prince of the realm conducts the Pharaoh's business, and it is clear that he is in a hurry

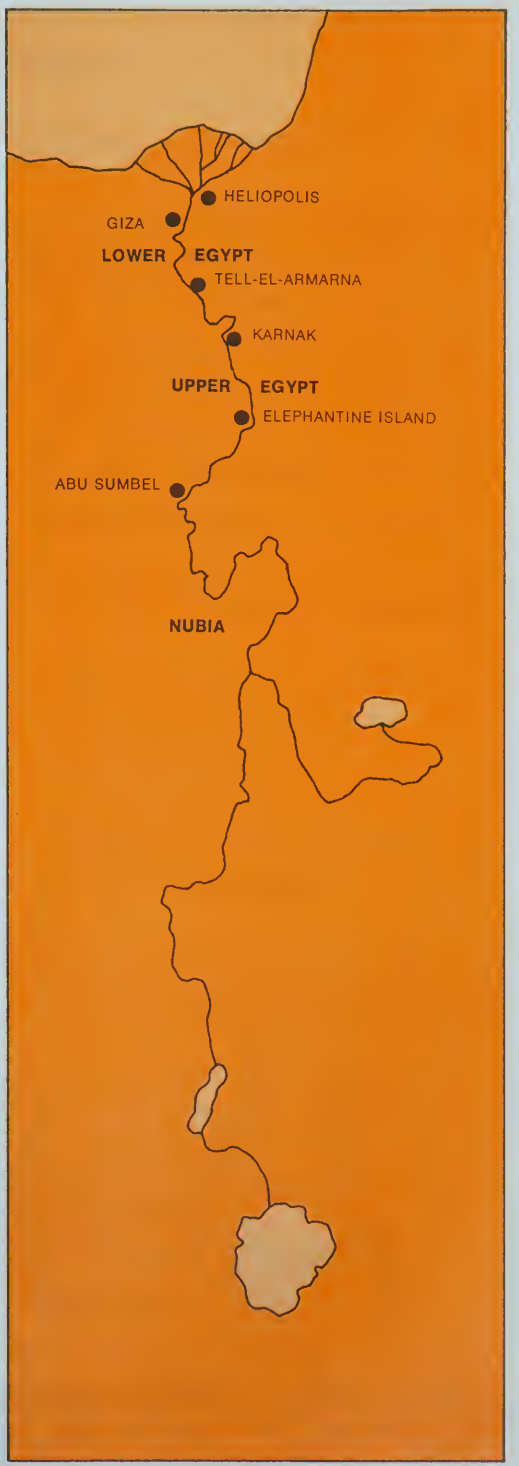
to return to Heliopolis. All eyes turn to view the distinguished official. For a brief moment we observe him seated beneath a striped canopy and attended by several servants. Then the great craft swings behind a second bend in the river, the high curving stern vanishes and the sound of the gong fades in the distance. The only sound now is the gentle ripple of water against our bow.

I turn to the pilot perched in the bow and ask him for our destination. He replies, "If the north wind holds, we are five days sail from Elephantine, our traditional meeting place with the Nubian traders. There we will exchange our grain for ivory and incense".

"What if the wind fails and you cannot reach Elephantine in time?"

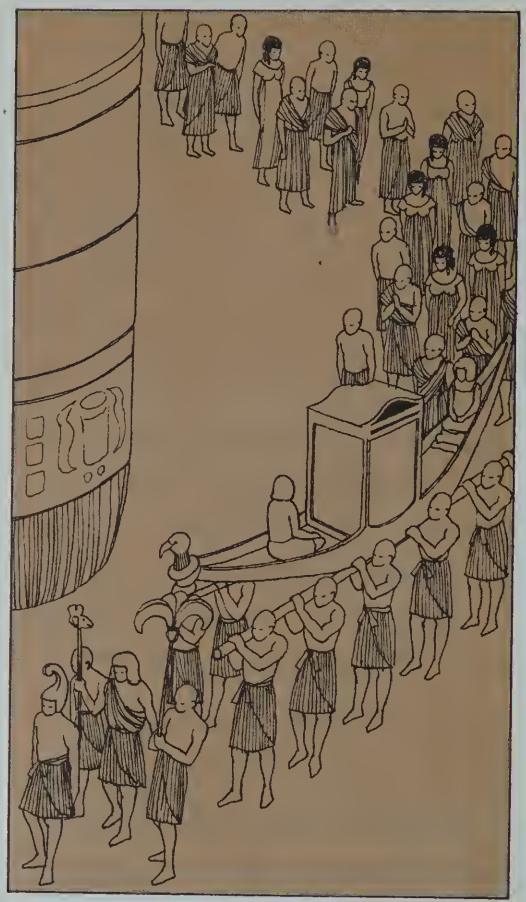
"At this season of the year the north wind won't fail. But even if it does, our crew can always un-ship their oars and reach the meeting place in good time."

At dusk, the pilot directs our ship toward a cove on the west bank. The crew furls the sail and the craft gently scrapes to a halt on the beach. The high bow of the ship hangs well over the beach so that we are all able to jump off without getting wet. Some craft have already beached for the night and others are following us ashore. Before long the river is cleared of all shipping, dusk turns to night, and small campfires light the length of the river bank.



DID YOU KNOW?

- The Nile swells rapidly between June and September, increasing from 523 to 8,500 cubic metres a second at Aswan (Elephantine). This means it rises from 26 to 32 feet above its lowest water level.
- The surging waters, fed by rain and melting snow, carry away tons of soil. In earlier times they left a cover of thick dark mud on the bordering fields.



We gather around our own fire, for the desert air is cool. Our crewmen, like sailors of every age,sing the traditional songs of their people. One of these songs goes like this:

The river is my doorstep,
The river is my sure path,
The river binds me to my brothers,
And brings me closer to my Pharaoh.
It leads me to the great north sea;
It lifts me to the marshes of Nubia;
The land it waters is the land of Pharaoh.
In him is my hope, in his land my home,
And in his river, my life.

1. You have read that the pilot of the ship had only one navigational piece of equipment. What was it? How did it work? Why was it necessary?

2. Modern navigators use charts. Why were charts unnecessary to the Egyptian river pilot?

3. All the ships proceeding downstream had their sails furled and simply drifted with the current. Why would unfurling the sail not speed the journey?

4. In a car, speed is calculated by means of a "clock" called a "speed-o-meter" (measure of speed). Why is the speedometer essential to travelling by car?

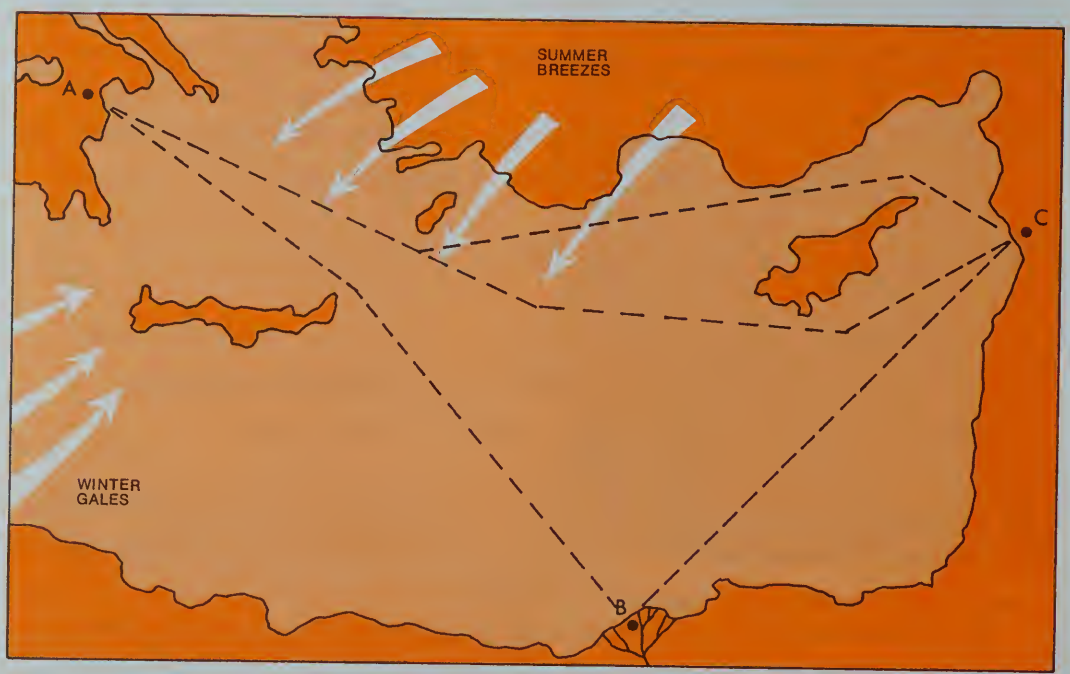
5. You may say that you can measure the speed of your car without the clock. How can you sit in your car, close your eyes, and calculate the speed of the car?

6. If you look out the car window, how can you calculate the speed?

7. The ancient Egyptian sailor did not have a clock. Was keeping a record of the time important to the journey by river craft? Check the story. Would the methods you suggest for calculating the speed of a car also apply to the river boat?

8. When we first went on board the ship, the pilot refused to beach his boat and forced us to wade out. Yet when night came on, the boat was beached and we were able to reach shore without wading. How can this be explained?

The Sea



We now meet a new body of water on which to sail. Can you imagine the river people with their flimsy craft and simple ways of water travel attempting to sail the routes marked on this chart? Do you know what it can be like out on the open sea? To them this would be a great and fearful step. In fact, the river men never really took such a step. Although they sometimes sailed the north sea, they never really learned to be seafarers or seamen in the true sense. It remained for less fortunate people, who wished to improve their livelihood, to risk venturing out upon the great salt sea. They could learn much from the river people, but the mastery of the sea would need a far greater knowledge of ships and water than the Egyptians could offer.

DID YOU KNOW?

- The sea was the highway of the Ancient World.
- Around 3000 B.C., sailors from Asia Minor, sailing from island to island northward across the unexplored sea, landed on Greece and settled there. Their own countries were crowded and it was important to find new lands.

"Any attempt to sail the route from A to B shown on the chart would require a much more seaworthy craft than that of the Egyptians." Assuming that this statement is true, what arguments can you find to support it? How would you change the boat in order to make it seaworthy?

To assist you, look at the following special chart that identifies various ideas you can use in presenting your arguments.

Designing a Seaworthy Ship

Here is a sample answer of what you might write:

1. (a) Since the *winds* change *direction* depending on the season, the simple *square sail* will not be good enough.
   (b) To overcome this problem, I suggest that we . . .

By now you should have prepared a list of weaknesses or shortcomings of the Egyptian craft and a similar list of changes you would like to make. The following pages will describe the building of a sea-going vessel. See how many of your ideas will be built into the new ship. In particular, see how many of your ideas were not used by the early boat builders, in each case asking yourself why your idea was not used. Discuss the problem with your class.

The ship we are going to describe was actually built, and it sailed the inland sea for many years. Although other types of ships were in use, the type we will build is a typical cargo vessel used for hundreds of years. We will call our ship *Kyrenia,* in honour of the port where her sunken remains were found in 1967. Archaeologists have raised her from the bottom, piece by piece, and reassembled her.

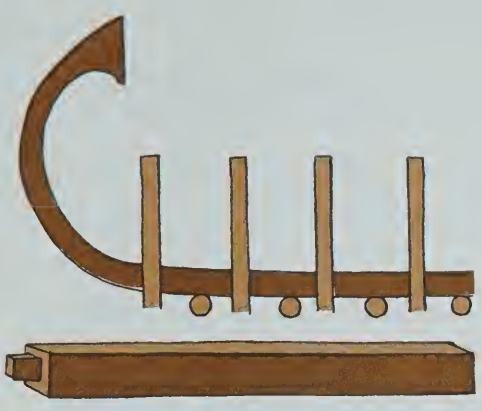
DID YOU KNOW?

- Kyrenia actually exists as a port and can be located in a good atlas. See if you can locate the port. Mark it on a map. Place an "X" just off the port and you will be marking the spot where our Kyrenian ship sank.

Building *Kyrenia*

Step 1: The Shipyard Is Made Ready

1. Why did the Egyptian boatbuilders not prepare extensive shipyards?
2. Explain the purpose of the forms and logs that you see.

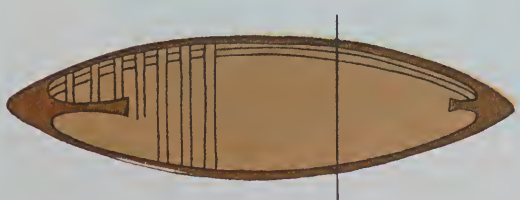


Step 2: Laying *Kyrenia's* Keel

1. What part of your body might we call your "keel"?
2. Why is your body's keel an important part of your body structure? Why is it necessary for sea-going craft to have keels?
3. "Both craftsmanship and available materials are important in the construction of a proper keel." What evidence is there to support this statement?

Step 3: Constructing *Kyrenia's* Hull

1. How do you distinguish a ship's hull from a ship's keel?
2. Compare the carpentry work with that of the Egyptians. Both display great skill. Do you agree? Both are sufficient for the needs and conditions to be met. Agree?
3. Joining the hull planks is what carpenters call "mortise and tenon". Find out what this expression means. Do carpenters still use "mortise and tenon"?
4. Curving the planks might be difficult. Can you suggest how the planking could be curved to fit the ship's design?
5. Can you explain why they bother to curve the planking at all?



Step 4: Ribbing *Kyrenia's* Hull

1. Study the human skeleton. Where are the ribs?
2. The purpose ribs serve in a boat is very similar to the purpose they serve in our bodies. Explain.
3. How could Egyptian boatbuilders succeed in building boats without ribs?
4. Study the items in the list on the next page. Does this add to our understanding of the need for rib construction? What can you deduce from the items on the list?

List of Things Found on *Kyrenia*

100	flat lead bracelet-size rings	1	iron chisel
4	jugs		coins (minted 306 B.C.)
	stacks of nuts (almonds)	4	bowls
403	amphorae	1	small pitcher
29	carved stone blades	4	plates
4	spoons	4	cups

copper nails in planking

DID YOU KNOW?

- By a wonderful modern invention, scientists can tell how old the *Kyrenia's* timbers are. They estimate that the timbers were cut about 389 B.C.
- By using this information and information gained from other pieces of evidence found on the ship, you could estimate the number of years the *Kyrenia* sailed the sea. Try it.

1. Examine the complete ship ready to sail. In what ways is she still similar to her Egyptian cousin?

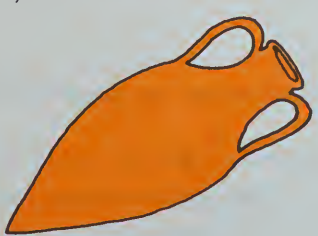
2. You will have observed that the *Kyrenia's* "power plant" is simply a large rectangular sail.
   (a) Why are rowers not used to assist the *Kyrenia's* movement?
   (b) "The type of sail seen here is still very crude, especially for sailing on the open sea." Explain this statement.
   (c) With this kind of sail, why is a high, curved stern necessary?
   (d) Lead rings the size of bracelets were found in the wreck of the *Kyrenia*. Archaeologists believe these were used for more efficient handling of the sail. Can you discover how they were used?

3. Why will ships like the *Kyrenia* require docks and harbours, such as those you see in the picture?

4. One reason why the Egyptians did not build docks was the rise and fall of the river level Is this a problem on the inland sea?

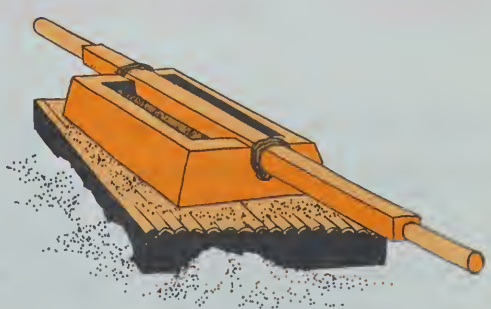
DID YOU KNOW?

- An amphora is a two-handed jug for storing and transporting wine. The narrow mouth is easily sealed.
- The amphora is made so that it cannot be placed in an upright position. (Why would this be?)
- It is made of pottery clay and is breakable. (Why?)



CAN YOU EXPLAIN?

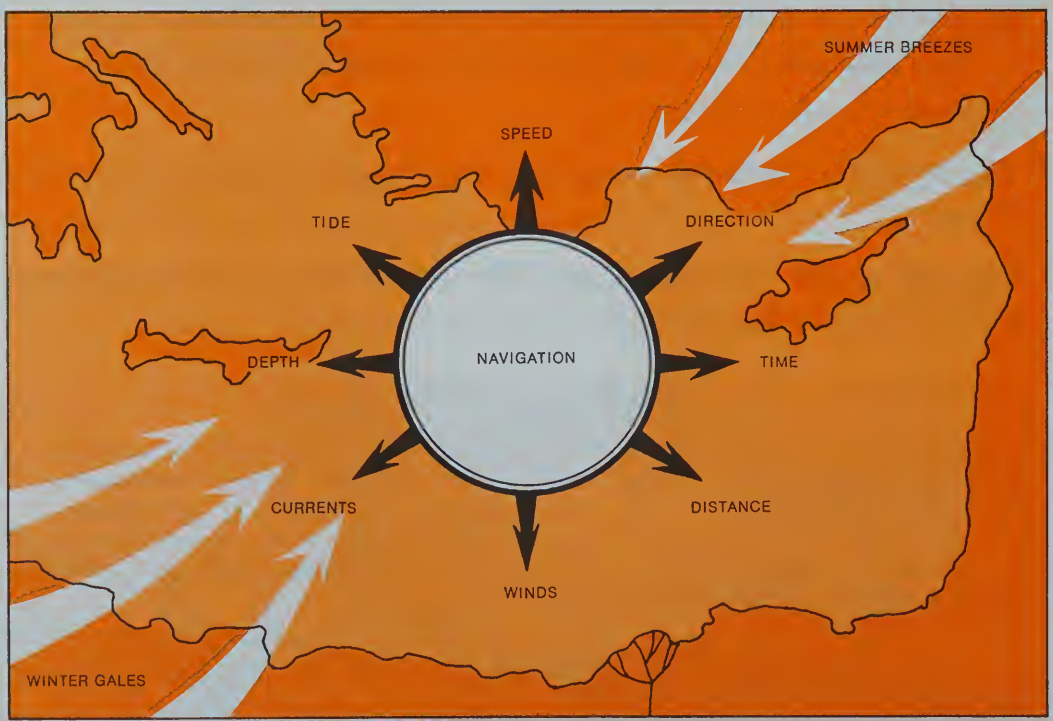
These carved stone blocks seem to fit in pairs. Here is how they are fitted together, the upper stone probably having a long wooden handle extending out to both sides. Can you explain the use of these stones?



We have now built the *Kyrenia,* a sea-going craft that can sail non-stop for several days and nights, that can carry a large enough cargo to make the trip worthwhile, that can stand the buffeting of open water, and that can give life-support to a crew of probably four or five.

But having built the *Kyrenia,* we now have the problem of sailing her. This is called **navigation**. After all, sailing along a river is hardly the same as sailing out into the open sea.

Here is another special chart. Using the chart, discuss why sailing on the sea presents many more problems in navigation than sailing on the river.



Write down statements that present the problems of navigation that are suggested by the chart. Here is a sample statement.

1. Unlike the river current that always runs in one direction, the currents in the sea can change and go in many directions. This means we cannot rely on the currents any more to take us toward our port.

2. Unlike the river where direction always . . .

If you have considered the problems of navigation, let us examine some of the answers that early navigators found to these problems.

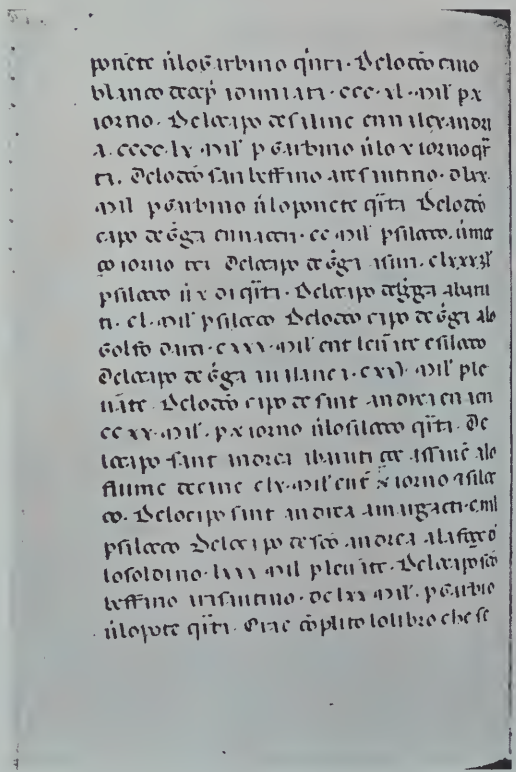
First, here is a chart used by navigators of the inland seas. The one you see here took many years to put together and it looks very complicated. This particular chart was drawn in the year 1275 A.D. and is known as the Carta Pisana.

SIMPLIFIED "CARTA PISANA" USED BY 13TH CENTURY MEDITERRANEAN PILOTS, WHICH PROVIDES NETWORK OF RHUMB LINES

1. Why is a chart such as this a necessary aid to sailing the seas? Why was it not needed in sailing a river?

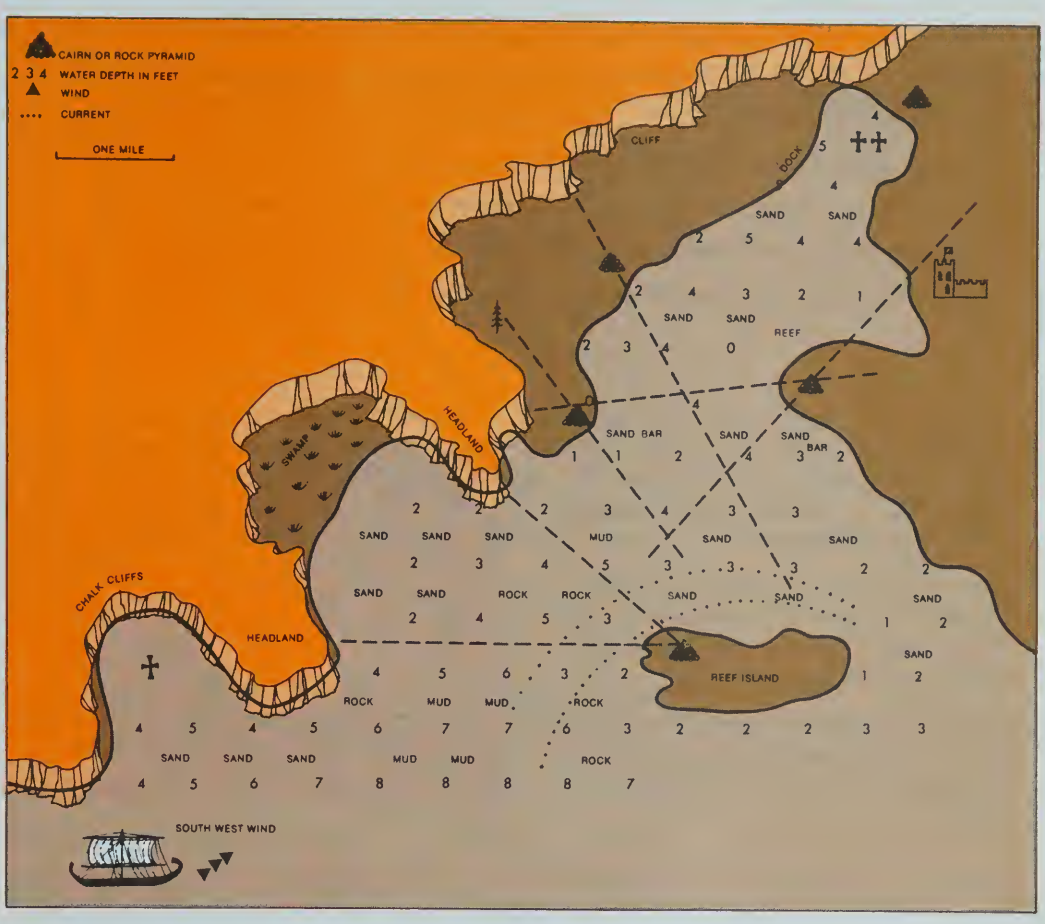
2. Look again at the navigational problems you discussed in relation to the previous chart. How does the Carta Pisana help to meet these problems?

In addition to the charts, most navigators carried a Mariner's Log. This Log provided the pilot with detailed information that the Chart might indicate but did not describe. Below is a sample of a Mariner's Log that would have accompanied our Carta Pisana. This particular Log was known to sailors as *Lo Compasso da Navigare.* On the left side is an original page from Lo Compasso. On the right side is an English version of the first page.



From Cadiz as far as Talfagar is 30 miles by the south-east. Opposite the said Talfagar in the sea, 7 miles south-west is a rock. And you must go between the rock and the land at a distance of 1½ miles from the land . . . From the island Isacaldera to the Rock of Gibraltar is 8 miles by the south-east and a little east. And on the said Rock is a castle and under the castle is a good port with a depth of about 8 fathoms.

1. Discover in what language Lo Compasso is written. What conclusions might we draw from such a fact?
2. These Mariner's Logs were generally called Portolano. Why is the name appropriate?
3. Locate a large map of Spain. See if you can chart on the map the route described on the page from Lo Compasso.



4. Your vessel has been anchored in the bay at point † waiting for a favourable wind. Your ship has full cargo and draws almost 4 feet of water. You are the pilot and are responsible for piloting the ship to the dock at point ††. Normally, you would read the notes in your Mariner's Log in order to assist your reading of the Chart. Unfortunately, the Log has been lost. Your task is to write a Log describing in detail your pilotage. It is important that you do this with great care so that others may use your Log in future.

5. Examine the Carta Pisana. How large an area is shown on the Carta Pisana? Of what use is the Carta Pisana to a ship's pilot? What evidence can you see on the Carta that by 1250 A.D. ships' captains were sailing beyond sight of land?

But to navigate beyond sight of land, the ship's captain faces the same basic problems in navigation that the crew of the space-going ship Apollo 8 encountered and entered into their Log Book. Although crude, the system of navigation developed for ships such as the *Kyrenia* was adequate for sailing the inland sea. Unable to sight land, the pilot had to use navigational tools that helped him determine where he was and where he was going.

The first two "tools" or aids that we will use cannot be shown since they are not what we usually think of as tools. You should be able to identify them after considering two Case Studies.

Case Study 1

1. What is the chief problem in navigating from Crete to Rhodes?
2. The passage is a good day's travel with a fair following wind. If you make the trip during the day, what aid will you rely on to help you to keep on course?
3. Assume you decide to return to Crete that evening. What navigational aid will you depend on to help you to keep on course?

Case Study 2

There is an old account of how ancient seafarers sailed right around the coast of Africa. The voyage took many months and the pilot probably depended on the same aids that you have just been using. However, as they proceeded southward they found to their astonishment that these aids were no longer reliable. Can you explain why?

Since the aids we have been using could not be used in cloudy or foggy conditions, the pilot needed some kind of instrument to help him determine his position. Following you see a display of such instruments. Try to determine what each is and how it assists in navigation.

A MAGIC STONE

"When clouds prevent sailors from seeing sun or star, they take a needle and rub its point on the magnetic stone. Then they transfix it through a straw and place it in a basin of water. The stone is then moved round and round the basin faster and faster, until the needle which follows it is whirling swiftly. At this point the stone is suddenly snatched away, and the needle turns its point toward Stella Maris. From this position it does not move."

(Written about 1240 A.D.)

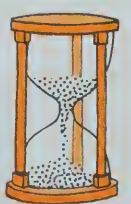
DID YOU KNOW?

- "Stella Maris" in English means Star of the Sea. In the words of one writer: "Behold our Stella Maris, the apex of the north, shining out on high. The sailor at night directs his course by it, for it stands motionless at the fixed hinge of the turning sky . . ."

1. 

a) Can you identify this tool?
b) How does it help the pilot?
c) Can you explain how it works? (Read "A Magic Stone" and the "Did You Know?" section about Stella Maris.)

2. 

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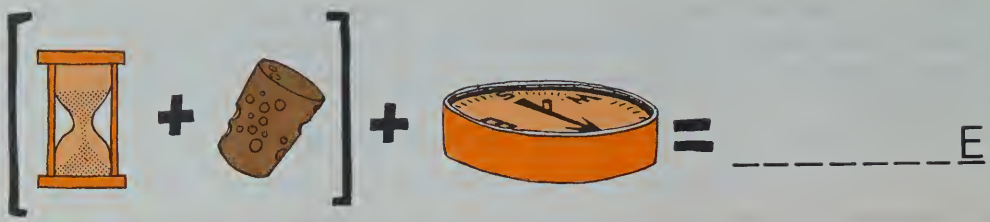
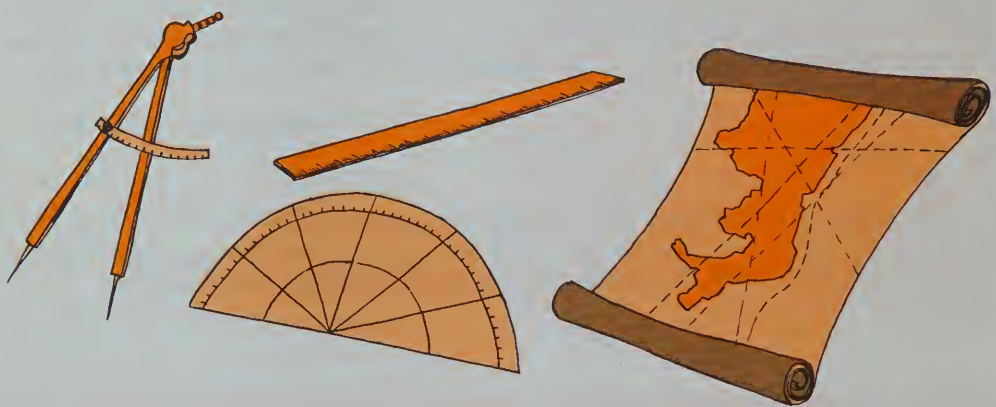
3. 

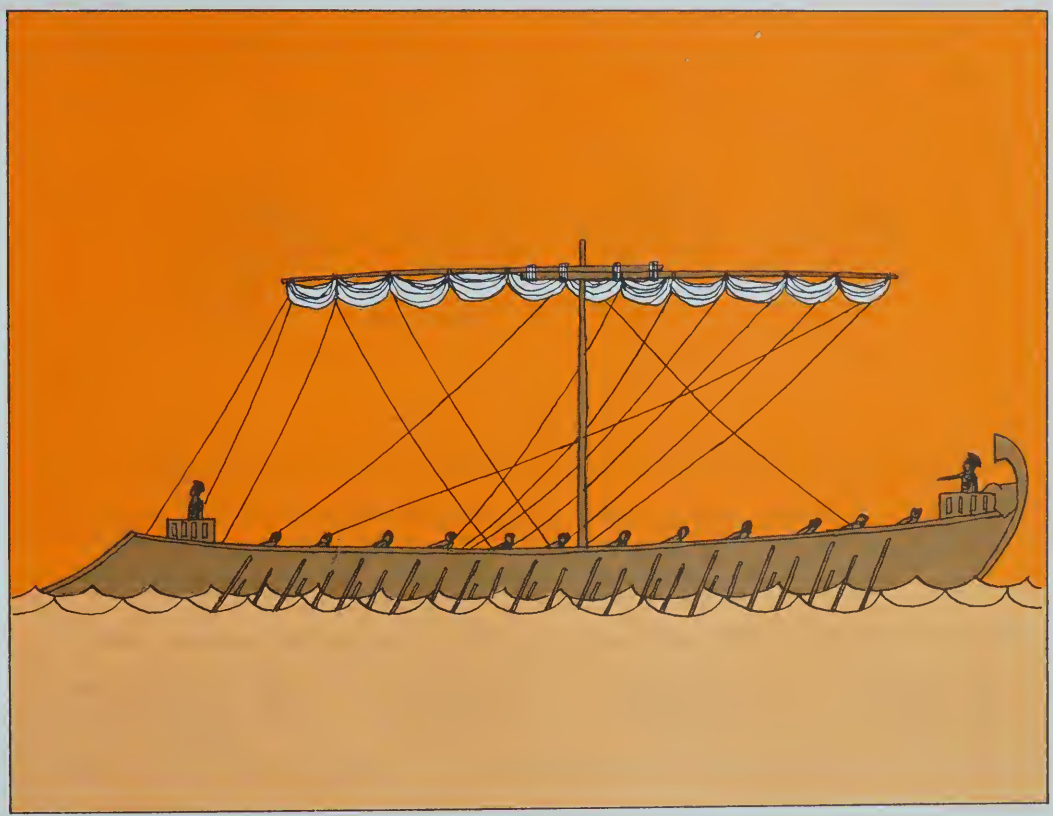
4. The information obtained through the above instruments must now be recorded by means of other tools on our navigation chart. How would the following items help the captain keep his record?



5. Although the systems of measurement are not very accurate, they are sufficient for travel on an inland sea. Why?

6. (As a test of your powers of observation, try to answer this question without checking back.) We know that Apollo 8 had a crew of three. How many men sailed the *Kyrenia?* Do you recall proof?

History books usually describe the ship you see here as the ship that travelled the inland sea. Certainly, with its three banks of flashing oars and its pointed ram-snout knifing through the water, it must have presented a most impressive picture. These slim triremes were extremely fast compared to the *Kyrenia*.



1. Why would this ship have limited use as a trading ship?

2. Of what use is this type of ship? Can you describe how this ship would perform its special task?

3. The structure of the trireme is box-like compared to the more rounded *Kyrenia*. How do you explain these two styles of construction?

Greek & Phoenician Settlement

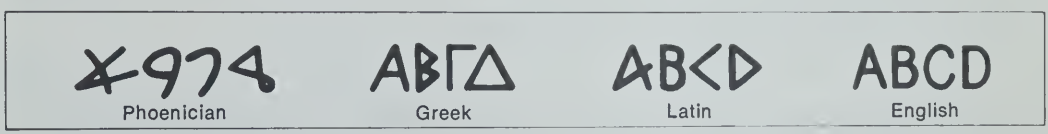
Here is a map of our inland salt sea. Two groups of people, the Greeks and the Phoenicians, found it necessary to secure lands beyond their borders. They expanded by sea, and in time had colonies scattered all around the inland sea. Our map shows some of these colonies. People who had to travel and live in new surroundings developed attitudes different than those of the Egyptians, who rarely travelled away from home. Here are descriptive words, some of which apply to the Greek sailor and some of which apply to the Egyptian river boatman. Make two lists: One of words you associate with the seafarer and one of words you connect with the river traveller.

daring	old	life	dependent
ambitious	independent	servant	questioning
secure	traditional	new	limitless
optimistic	adventurous	settled	freedom
death	curious	fatalist	competitive
limited	self-satisfied	individualist	horizon

The sea shown in the map was often called the Great Inland Sea. Later it was called Mare Nostrum and also Mediterranean. The latter name is still used and stems from two words, "medi" and "terra". Find out what they mean. How does its meaning express the attitudes of the people who lived along its shores?

Silver coins discovered on board the *Kyrenia* indicate the efficiency of the Greeks' trading. How do you think coins and efficient trading are related?

"The lines of writing or script represent an element that was important in the development of a widespread system of trade and settlement." Support this statement.



DID YOU KNOW?

- Colonization began around 800-600 B.C., as Greece became overpopulated.

"Societies based on sea power are superior economically, politically and culturally to any society based on river power." Use the map to confirm this statement.

Although sea power can help a nation achieve a superior society, it can in time cause its destruction. If you can see what is happening on the map, you can anticipate how this destruction might occur.

The Ocean

THE WORLD ACCORDING TO HECATAEUS

1. With the help of a modern map of the world, draw a line around the area in this map that seems to be drawn reliably. Use the Ancient Atlas section to gain a clearer indication of what these old maps were like. Colour in all the land area within your circled area.
2. Label any landforms and bodies of water named on the modern map that can be easily recognized on the old map.
3. In drawing your line, how did you decide regarding the following?

Nile River	Caspian Sea
Indus River	Red Sea

4. Can you give reasons why the map-maker would complete his map without reliable knowledge of some regions?
5. Although most Greek map-makers believed the world to be round like a ball, how might uninformed people, looking at the map, come to think of the world's shape?

DID YOU KNOW?

- A group of Greek thinkers said that a sphere or globe was the only perfect solid shape and it alone was worthy of being the home of man.
- The shape of the early Greek map caused many people to refer to it as a "dinner plate" shape.

6. Suppose you were a sailor, and the King of Carthage instructed you to set sail for the land of the Issedones as seen on this map. What reasons would you give for advising against this voyage?

The following map of the world was the work of Claudius Ptolemy (tol'a me) and was probably completed about the year 150 A.D. This means it is about 500 years later than the early Greek map.

PTOLEMY'S WORLD OUTLINE FROM THE ROME EDITION OF 1490

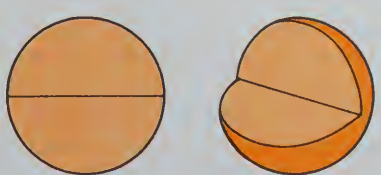
1. How has Ptolemy tried to avoid any misunderstanding as to the shape of the world?

2. Examine the detail of Ptolemy's map. How much more correct knowledge of the world has been added since the earlier map? How would Ptolemy get the information he needed?

Ptolemy said that to draw a map properly required a mathematical structure on which the features of the land could be measured and located. How has Ptolemy attempted to do this? Can you understand his structure?

Ptolemy said that his world divided into 360 units or degrees. Using the scale placed on the map and measuring along the equator, calculate the size of Ptolemy's world.

You have enough information on these pages to estimate the approximate distance around the world. Compare your estimate with Ptolemy's. How great an error did Ptolemy make?

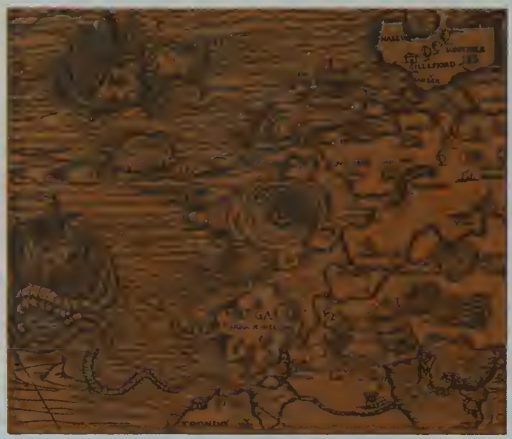


DID YOU KNOW?

- 360 degrees make a complete circle. Here are two examples.

- A degree measured at the equator measures approximately 70 miles.

"The Ptolemy map was greatly admired because it was so scientifically prepared." What does this mean? Do you agree?



THE HEREFORD WORLD MAP 1280 A.D.

This map of the world and the sea chart were prepared about 1300 A.D. Since this is more than a thousand years after Ptolemy, we can expect considerable improvement in the map of the world.

1. Note how religion has altered the making of the map of the world. To what extent do you find this an improvement?
2. The design of the maps of this period has caused modern scholars to refer to them as T.O. maps. Can you see why?
3. The sea chart on the right reveals the fears and superstitions of the age. Suppose you are a sailor about to leave. Describe your fears.
4. If this is the kind of map people believed in, how would you describe the people of this period?

WHAT DO YOU THINK?

"Some argue that the earth is a sphere! How can anyone be so foolish as to believe that there are men whose feet are higher than their heads, or places where things may be hanging downward, trees growing backward, or rain falling upward?"

If the knowledge of the world had remained at the level shown on this last map and chart, no ship's pilot would have dared to venture very far from shore. However, by the fifteenth century (1400-1500), sailors were talking of sailing into the ocean sea beyond the sight of land. Why would any man risk his life in such a venture. Two changes must certainly have taken place. First, it must have become clear that there was a great deal to be gained. Secondly, knowledge of the world must have greatly improved from the days of the maps we have just examined. No country would support a sailor without hope of profit, and no sailor would risk certain death.

If you examine the maps that follow, you will find answers to the first change that was taking place.

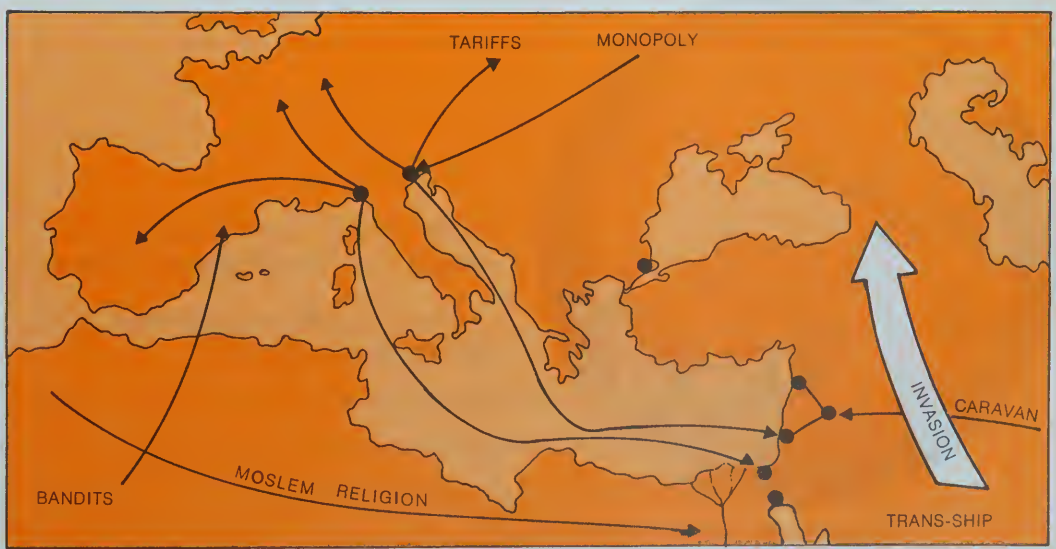
EUROPE: 1400 MARCO POLO'S EAST

1. How do these maps suggest trade opportunities?

2. If you had lived in London, what five products of Asia would you be anxious to gain through trade?

3. If you had lived in Hangchow, what would you want in exchange?

Despite the opportunities for trade, the map you see below suggests several reasons why people in countries such as Portugal, Spain, England, and France found it increasingly difficult to conduct trade for the products of the East. Some of the labels around the map may need checking in the dictionary. Once you understand the labels, see if you can apply what they mean to the map. In each case you should find reasons why people in Spain, Portugal, England and France would begin a search for ways to share in the wealth of the Far East.



At this time, many of the old ideas about the world were being discarded. One man who gave leadership to the new theories of map-making was Prince Henry of Portugal.

As a young prince, Henry had fought the Turkish invaders and pushed them back into Africa. His little state of Portugal boldly looked out across the sea to where the coast of Africa disappeared beyond Cape Bojador. From this point, Prince Henry developed a great and ambitious idea. "What if we dared to sail the coast of Africa? Fra Mauro and other map-makers tell me that our ocean is linked with the Indian Ocean. If we could somehow sail around the bottom into the Indian Ocean we could do two things. First, we could take our ships directly to the treasure of India and avoid the costly caravan routes. Second, we could join forces with his Most Christian Highness, Prester John, whose kingdom lies somewhere in Africa. As allies we could strike the Turkish infidel from both sides."

To most people Prince Henry was a dreamer. Who would dare to sail beyond Cape Bojador? Beyond it the sea boiled. Beyond it the skin turned black. Beyond it the treacherous currents made returning impossible. Besides, the greatest authority on Africa was Claudius Ptolemy, and his maps clearly showed the Indian Ocean to be landlocked.

There were a few, however, prepared to risk the dangers. If the Prince was right, if Africa could be rounded, if the sea didn't boil, and if he didn't fall off the edge of the world, the profits from a cargo of India's spices would be beyond imagination. The old caravan trade had been very costly, especially for countries as far west as Portugal. In addition, the Turks

FRA MAURO MAPPA MUNDI

DID YOU KNOW?

- In the days before refrigeration, spices from the East were used to preserve meat.
- As the population of Europe rose, so did the demand for spices.

had successfully invaded all the eastern Mediterranean and had seized the trade routes. Many of these invaders refused to trade with Christians and those who did charged very high prices. All Europe yearned for the pearls, the silks, the spices, and all the other wonderful products that had at one time come to them over the caravan trails.

The story of Prince Henry does not end in dreams. He was much more than a dreamer. He called together scholars from all over to hear the latest ideas on maps, ships, charts, and instruments. They met in the little town of Sagres overlooking the trackless sea. It was here at the School of Sagres that the plans for his great idea were worked out and the newly-designed ships made ready. In a sense, Sagres was the Cape Kennedy of its day. What the "argonauts" of that day accomplished can be be seen on the map. There were many brave pioneers who, urged on by Prince Henry, dared to sail into unknown waters. One, Gil Eannes, was among Henry's most capable captains.

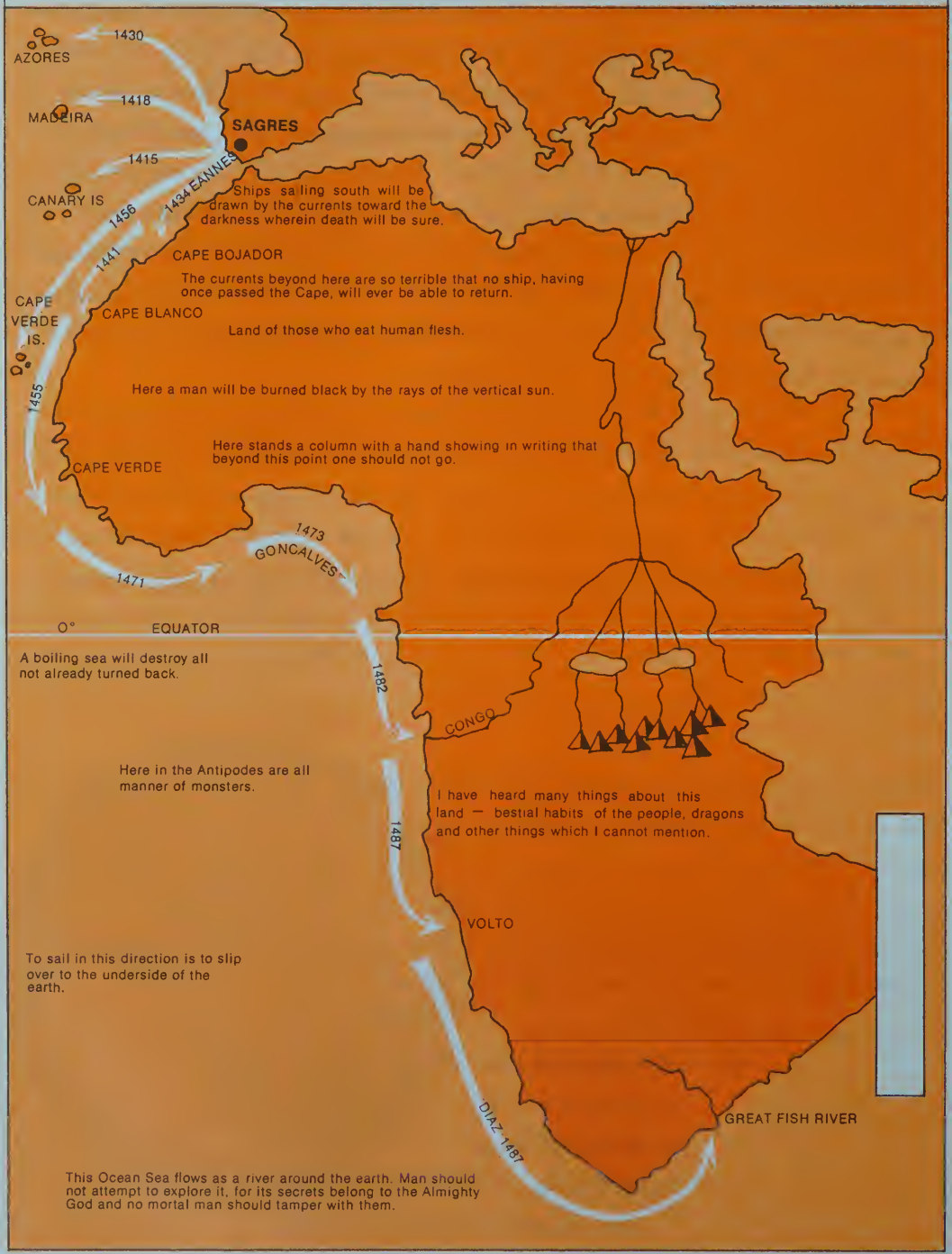
ARGONAUTS

This name was given to ancient seafarers, whose "argosy", or journey, led them to many adventures and dangers.

It was Gil Eannes that Henry ordered to round the treacherous Cape Bojador. Although the cape appears small on a map, the terrible currents and reefs, along with the terror of the unknown "sea of darkness", make the rounding of Cape Bojador a tremendous breakthrough, and place the captain who does so in the forefront of important explorers. The feat is comparable to John Glenn's first passage into space. After the success of Eannes, there was no stopping the daring of the Portugese.

The Lusiads (The Portugese)
"In golden treasures rich, distant Cathay
And all the farthest Islands of the East
And all the seas, to them shall homage pay."
(from an epic poem written in 1572)

SAGRES: The Cape Kennedy of the 15th Century



While the Portugese were advancing slowly down the coast of Africa, an Italian sailor named Christopher Columbus was offering the King of Spain a wild plan whereby he would undertake to sail west to the East. His new theories began to emerge when copies of Claudius Ptolemy's old map were rediscovered and carefully studied by scholars.

1. Why do you think the Spanish Government's decision to aid Columbus might have been influenced by the Sagres map?

2. From the evidence obtained from the Sagres map, why might sailors be more willing to sail with Columbus?

   A scholar by the name of Paolo Toscanelli also played an important part in influencing both Columbus and the king of Spain. Toscanelli wrote several letters to these men, a sample of which follows.

Florence
June 24, 1474

Paul, the Physician to Cristobal Colombo, greeting. I perceive your magnificent and great desire to navigate from the parts of the east to the west and which can best be demonstrated on a round sphere. The voyage is not only possible but certain to yield incalculable profit and very great fame.

I send to you a copy of a sea-chart made by my own hand showing the known coast and islands whence you must begin your journey westward, and showing the latitude you should keep. By my chart from Lisbon to Kinsay (Hangchow) due west is 26 spaces, each space measuring 250 miles*. This great city's name signifies the City of Heaven. But from the island of Antilia to the island of Cippangue (Japan) is only ten spaces.

You must not be surprised if I call the parts where the spices are "west" when they usually call them "east", because to those always sailing west, those parts are found by navigation on the underside of the earth. But if by land and the upper side, they will always be found to the east.

Toscanelli

---

*The Roman mile used here is only ¾ of a nautical mile.

TOSCANELLI'S MAP OF 1492

1. Like Ptolemy, Toscanelli believed the world to be a sphere, or ball. How can you tell this from his sea-chart?

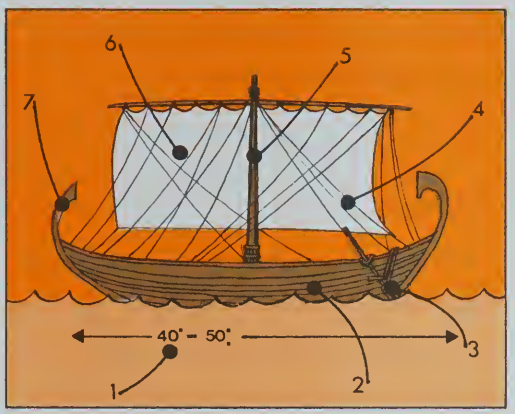
2. Calculate in a straight line the distance from Spain to Cathay according to Toscanelli. Compare the straight-line distance from Spain to China on a modern map. How do you explain the map-maker's error?

3. Columbus used Toscanelli's map to persuade the Spanish King and Spanish merchants to support a voyage to the west. If this map had not made the error noted in question 2, it is doubtful that he would have sailed. Why?

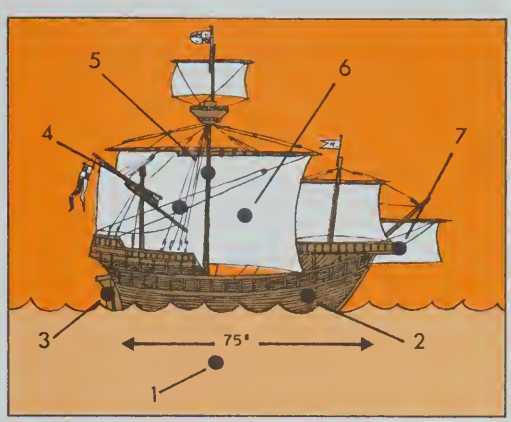
4. Besides the error in distances, what is the most obvious error on the Toscanelli map?

Having considered two major reasons why men might dare to sail out into the trackless ocean, let us examine two other important matters. We agree that it would be nice if we could sail directly to Cathay and bring Spain the rich trade of the East. We agree that many of the old myths and fears don't frighten us much and the new maps tell us that the world is round and that Cathay lies less than 5,000 miles to the west. But are ships like the *Kyrenia* stout enough to travel such great distance on an open sea? And is the navigational equipment that we used in the Mediterranean accurate enough for such a venture?

THE KYRENIA



THE SANTA MARIA



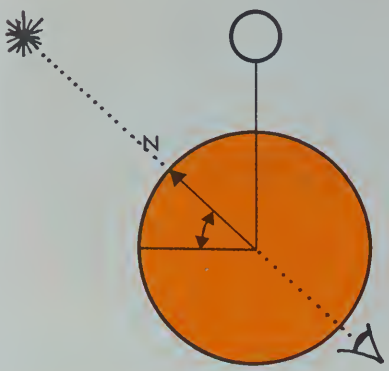
Each of the numbers suggests a necessary change in the ship. Identify each of the changes. Why have such changes been necessary in order to venture upon the ocean? Columbus urged that he be provided with a fleet of ships and it was agreed to finance a fleet of three ships. How would you help Columbus argue the need for at least three ships?

DID YOU KNOW?

- A Caravel could carry more than several caravans. It was safer as well as faster than travel by mule or camel.
- Prince Henry the Navigator's captains sailed ships of 100 tons. A ship's size in those days was measured in the number of "tuns" (casks of wine) it could carry.
- The *Enterprise,* which is a modern, nuclear-powered aircraft carrier, is listed at 85,000 tons.
- The supertanker, *Manhattan*, is registered at 137,068 tons.

Since we found that a good many changes were necessary in ship construction, it is probably true that the old navigation instruments also had to be improved. Here we see one change. Instead of estimating speed by tossing a cork chip off the bow, sailors began using the instrument shown here. Can you discover how it works? It is used along with the hour glass.

Since it was difficult to fix one's position after familiar landmarks were out of sight, sailors relied on the astrolabe to gauge their position in terms of latitude.



ASTROLABE

This is the instrument the navigator used to determine latitude.

LATITUDE

Latitude is distance measured in degrees north (or south) of the equator.

DID YOU KNOW?

- North was indicated on the astrolabe by a fleur-de-lis. Other points were not indicated by numbers, but by markings of different shapes, lengths and colours. This was done because many could not read numbers.

1. Why would the pitch of the ship make accurate readings difficult?

2. At what latitude is the ship, according to the reading on the astrolabe?

3. Why would two men be needed to use this instrument?

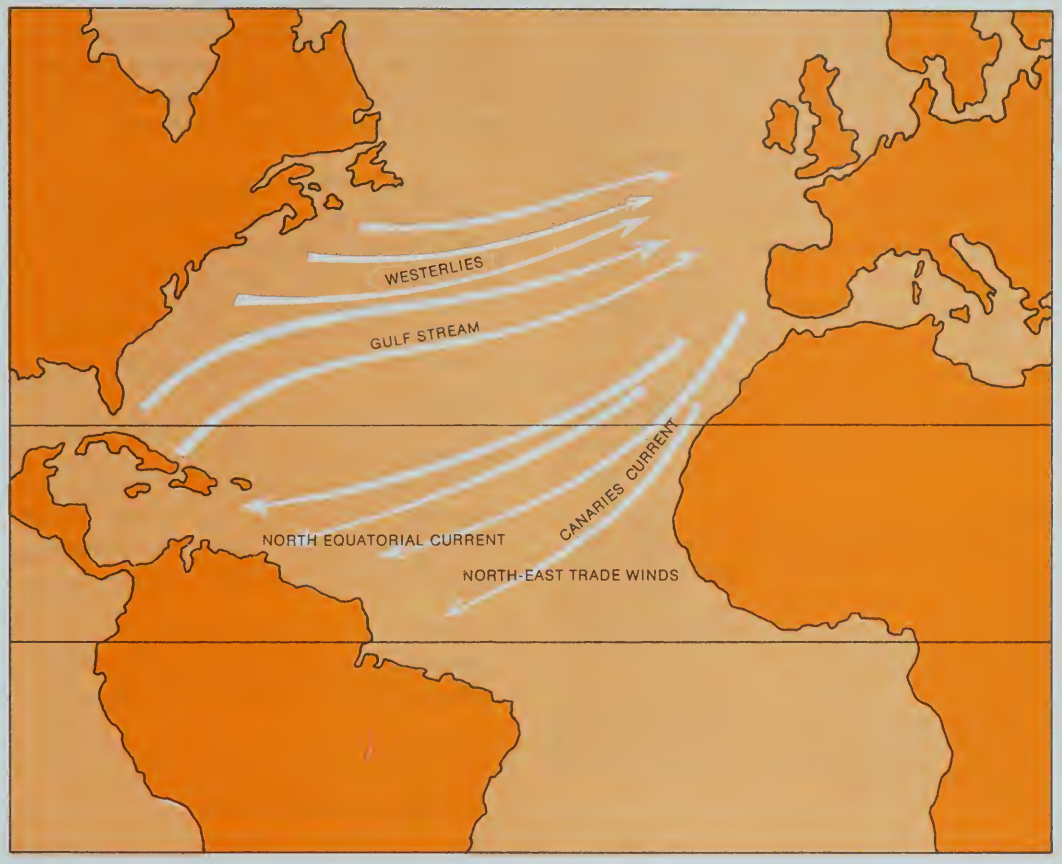
4. What similarities do you notice in the following words?
   (a) astronaut
   (b) astrodome
   (c) astronomy
   (d) astrolabe
   (e) astronomical

5. Look up in a dictionary the meaning of the Greek word, *astron*.

6. If we are "shooting the sun", why would it be necessary to adjust the astrolabe readings depending on the time of the year?

7. (a) If it is December 21 and your astrolabe reading is 20° (north), what is the true reading?
   (b) If the date is June 21, and the astrolabe reads 12° (north), what is the true reading?
   (c) If the date is September 21, and the astrolabe reads 23° (north), what is the true reading?

8. For most occasions why would a prepared table of adjustments be necessary?



1. If Columbus had set sail from Spain just knowing about winds and currents and their direction, which way would he have sailed to go west most easily?

2. How should he return to Spain from the New World?

3. Geographers of the 1400's believed Japan to be about 20° – 25° N of the equator. How did this information influence Columbus? Were those early geographers correct in their belief?

4. What is 'parallel' sailing? Why was Columbus able to practise 'parallel' sailing?

5. Why was he unable to determine accurately his position while at sea?

6. Start a log of your own to go along with the journey of Columbus. To do this, use words and ideas in his log which refer to:

TIME **DISTANCE** **DIRECTION** **SPEED** **CRAFT**

Friday, August 3rd.

On Friday, the third day of August, of the year 1492, at eight o'clock in the morning, we set sail and were able to catch the outgoing *tide* and clear the *bar* at Saltes. We went with a strong breeze sixty miles to the south before sunset. Afterwards we held to the southwest and south-by-west, which was the course for the Canaries.

1. Compare this departure log with the departure log of Apollo 8.
2. This was an ebb tide. Explain .
3. Why does a bar exist at the mouth of the river at Saltes?

Saturday, September 8th.

It began *to blow* from the *northeast,* and we shaped our route and *course to the west.* We shipped much *sea over the bows,* which made progress slow, and that day and night we went *nine leagues.*

4. Draw a sketch-map to illustrate what was happening. Make sure you use the italicized words.

DID YOU KNOW?

- The Carnary Islands are named for the dogs which the Romans saw there (Latin: canis).
- It was not until 1270 that the Canary Islands were rediscovered.
- A league (leeg) is a measure of distance and equal to three miles.

Sunday, September 9th.

We made fifteen leagues this day. I have reckoned the distance as less in order that the crews might not become disheartened or alarmed.

Tuesday, September 11th.

We are on course due west and have made twenty leagues or more. During the night, we went some twenty leagues more, but I reckoned no more than sixteen.

5. The September 9 and 11 entries seem strange. If we were crew members, we would feel heartened to know we had gone the greater distance so that we might reach our destination sooner. Since Columbus knew his crew better than we do, how would he explain his actions?

Thursday, September 13th.

We are on course due west and have made thirty-three leagues counting both the day and night. I have entered less into the log. The currents have been against us.

6. What is a current? Why are there currents in the ocean? Find a map in an atlas that marks ocean currents.

7. If the ships are in the North Equatorial Current (see page 55), how can the currents be against them?

Friday, September 14th.

The caravel Nina reports seeing a tern. These birds never go more than twenty-five leagues from land.

DID YOU KNOW?

- This ship is said to be *reaching*. This is the simplest point of sailing. Wind is on the *beam* (side). Boat is on course (to west). Sail is let out until leading edge *(luff)* flutters.

Saturday, September 15th.

Early this evening we saw fall from the sky a marvellous branch of fire. It fell into the sea at a distance of four or five leagues from us.

8. Examine this entry. How correct is this statement? What do you suppose the "fire" might have been? Do you think the entry shows any fear? Why is courage an important quality in the explorer?

Monday, September 17th.

The current is with us. This day and night we sailed fifty leagues and more. The pilots took a compass bearing on the North Star and found the needles *declining* to the north-west a full degree. The sailors were alarmed. I have told them that the Star appears to have changed position and that the needles are true.

9. Ask your science teacher to explain the problem described in the September 17 entry.

DID YOU KNOW?

- It is only with the help of science that man has been able to succeed in discovering the safest routes across the oceans.

Tuesday, September 18th.

Today we made fifty-five leagues day and night. But I have entered no more than forty-eight. Alonso on the Pinta has sighted a great crowd of birds heading west and believes we should sight land tonight.

DID YOU KNOW?

- The practice of following the flight of birds assisted the Portugese in the discovery of several previously unknown islands.
- In 1431, one of Prince Henry's captains found the Azore Islands.
- Açor, in Portugese, means hawk.

Wednesday, September 19th.

Today the pilots estimated their position. The pilot of the Nina makes it 440 leagues out from the Canaries. The pilot of the Pinta makes it 420 leagues. The pilot of the Santa Maria, only 400 leagues.

10. The September 19 entry shows a difference of 120 miles in the pilots' estimates. How do you explain the differences? Why would you expect the Santa Maria's to differ?

Friday, September 21st.

Today we saw a whale, which is a sign that we are near land, since the whale always remains near it.

11. Would you explain this entry in terms of ignorance, wishful thinking, or deliberate fibbing?

Saturday, September 22nd.

There has been a change in the winds and we are sailing into a strong westerly headwind. I am pleased, for my people had begun to think that in these seas no winds ever blew to carry them back to Spain.

12. Study the route followed by Columbus shown on the map on page 55 . Take an atlas and find a map showing wind patterns. Relate this information to the fears of the crew noted in the September 22 entry.
13. How do you explain strong westerly winds blowing in the region of the north-east trade winds? Use the diagram below. Locate the three ships.

Tuesday, September 25th.

We are now in the vicinity of islands marked by our mapmakers as St. Brendan, Brazil and Antilla. The reason we have not as yet sighted these islands must be due to the currents which have carried our ships north-eastward.

Alonso on the Pinta has sent a signal that he has sighted land. We all fall upon our knees to give thanks to Our Lord. Gloria in Excelsis Deo. We have changed course and are following the Pinta. We will hold this course during the night.

14. Columbus' explanation for having missed the islands located on the sea-charts is a good one. Could you suggest to Columbus another good reason why he missed these islands? Why is your explanation reasonable?

Wednesday, September 26th.

Disappointment. What was thought to be land was only a cloud.

DID YOU KNOW?

- Due to certain strange weather conditions that occur from time to time west of the Canaries, a phantom island, or a mirage, often appears on the horizon at dusk.

Monday, October 1st.

My pilot this day calculates we have gone 578 leagues westward from the Canaries. This I have told the men, but the true distance of 707 leagues I have kept a secret.

By this time Columbus and his crew had sailed over twice as far beyond sight of land as anyone had before. All signs had failed and landfalls had proven false. The ships leaked and might reach a condition in which repairs could not be made at sea. To make matters worse, the worried pilots had revealed Columbus' false reckoning of distances to the sailors.

Sunday, October 7th.

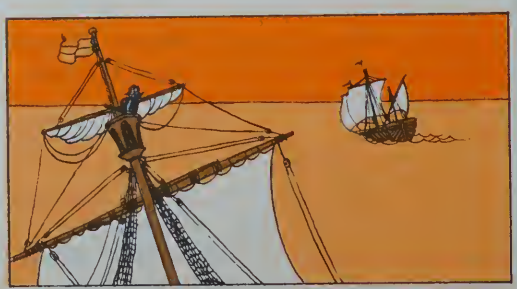
At sunrise the caravel Nina hoists a standard and fires a bombard, as a sign that land is in sight. But by evening the sighting has proven to be false.

Tuesday, October 9th.

All night we have heard birds passing.

Wednesday, October 10th.

My men are complaining they can bear no more. The voyage, they say, is too long.



15. This entry tells why the crew are complaining. In view of their complaints, has Columbus' practice of withholding the true distances been right or wrong?

Thursday, October 11th.

A sailor Rodrigo de Triana, look-out on the Pinta, has shouted, "Tierra! Tierra!" The time is late. It is difficult to tell.

Friday, October 12th.

As 2 a.m. this October 12th, 1492, we have indeed the sight of the land. It is only two leagues away.

At dawn we see naked, dark-skinned Indians. They call this island Guanahani.

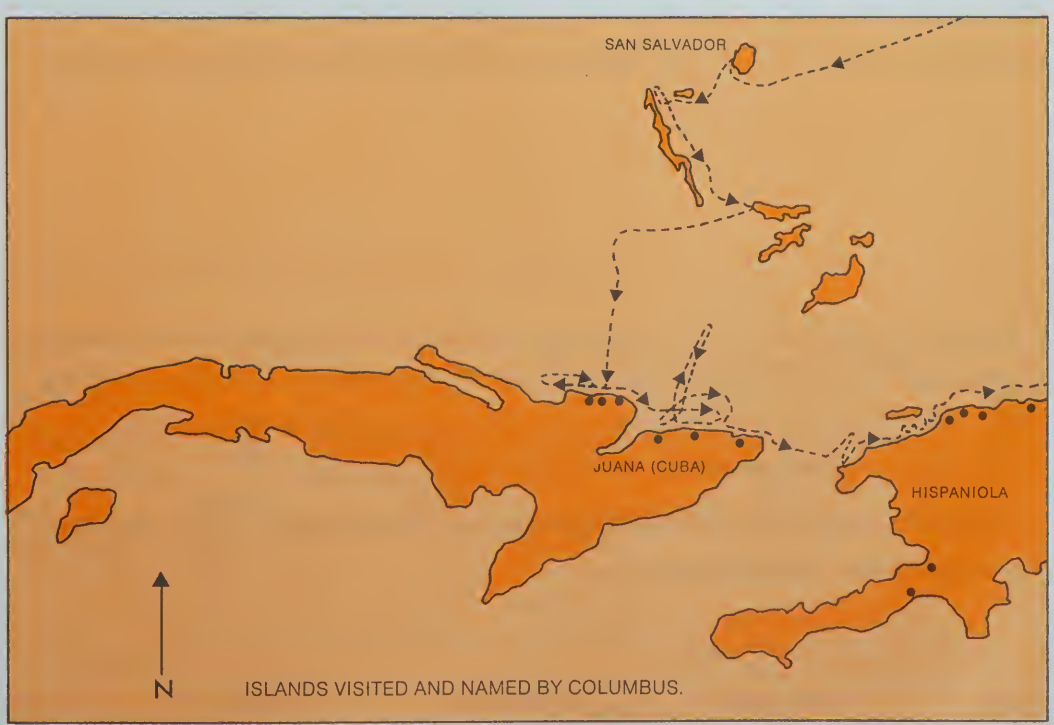
I go ashore in an armed boat. I take with me the royal standard. I set my foot upon the soil and proclaim this place Fernandez Bay and take possession of it for the King and Queen.

So far we have seen no monstrosities. On the contrary, the whole population is very handsome. Their hair is not curly, but loose and coarse. They are not negro, but rather the colour of the Canarians. They should be good servants and I believe would easily be made Christians.

16. Why is this comment about monstrosities written into the record?

THINGS TO DO

Columbus made four journeys across the Atlantic Ocean to the New World and came within a few miles of learning of the Pacific. Read some of the material listed in the bibliography at the end of the book to discover the excitement of Columbus' voyages.



ISLANDS VISITED AND NAMED BY COLUMBUS.

Man's Technology-Man's Travels

Since the days of Christopher Columbus, man's endless journey has taken him into the depths of the sea and out into space. Although man is physically weak, his creative mind has enabled him to meet the challenges of navigation and exploration. He has created craft which travel at extremely high speeds for tremendous distances. He can accurately determine time and direction by using the amazing instruments developed. Man's advances in technology have enabled him, a two-legged land dweller, without fins, wings or gills, to be at home in the air or in the water.

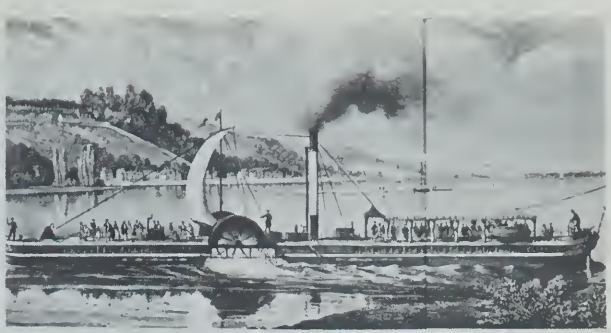
DID YOU KNOW?

- Measuring distance East-West is known as measuring *longitude*. Columbus' calculations going west were not precise since he could not determine distance, having no accurate clock. It was not until 1735 that an accurate sea-going time piece was available. After this, navigators could accurately determine longitude.

When examining the pictures, diagrams and questions which follow, keep in mind the criteria which encompass all man's travels:

TIME **DISTANCE** **DIRECTION** **SPEED** **CRAFT**

Winged Balloon



First Successful Steam-Powered Boat

Paddlewheeler Robert E. Lee

Turn back to page 6, "A Simple Sailing Exercise," and answer questions one to five. Compare your original answers with your most recent thoughts.

Compare the Egyptian river boat, the *Kyrenia,* the Santa Maria and these ships on the basis of:

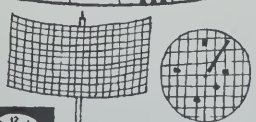
a) their speeds
b) their instruments
c) their purposes.

Account for the differences between the two steam-powered ships.

Cut away side view submarine

How does the design of this CRAFT enable man to take his environment with him?

Radar scope and screen



Of what use is the radar scope and screen in navigation? What does it help to determine?

Accurate chronometer

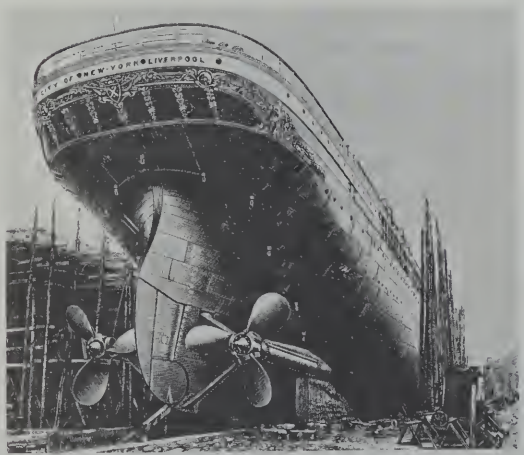
What is the relationship between time and distance?
When was the first accurate chronometer constructed?

Sonar

How does the sonar take the place of the lookout in the crow's nest? What does it help to determine?

Considering the various aspects of *time, distance, direction, speed* and *craft,* what questions come to mind when you look at these two pictures?

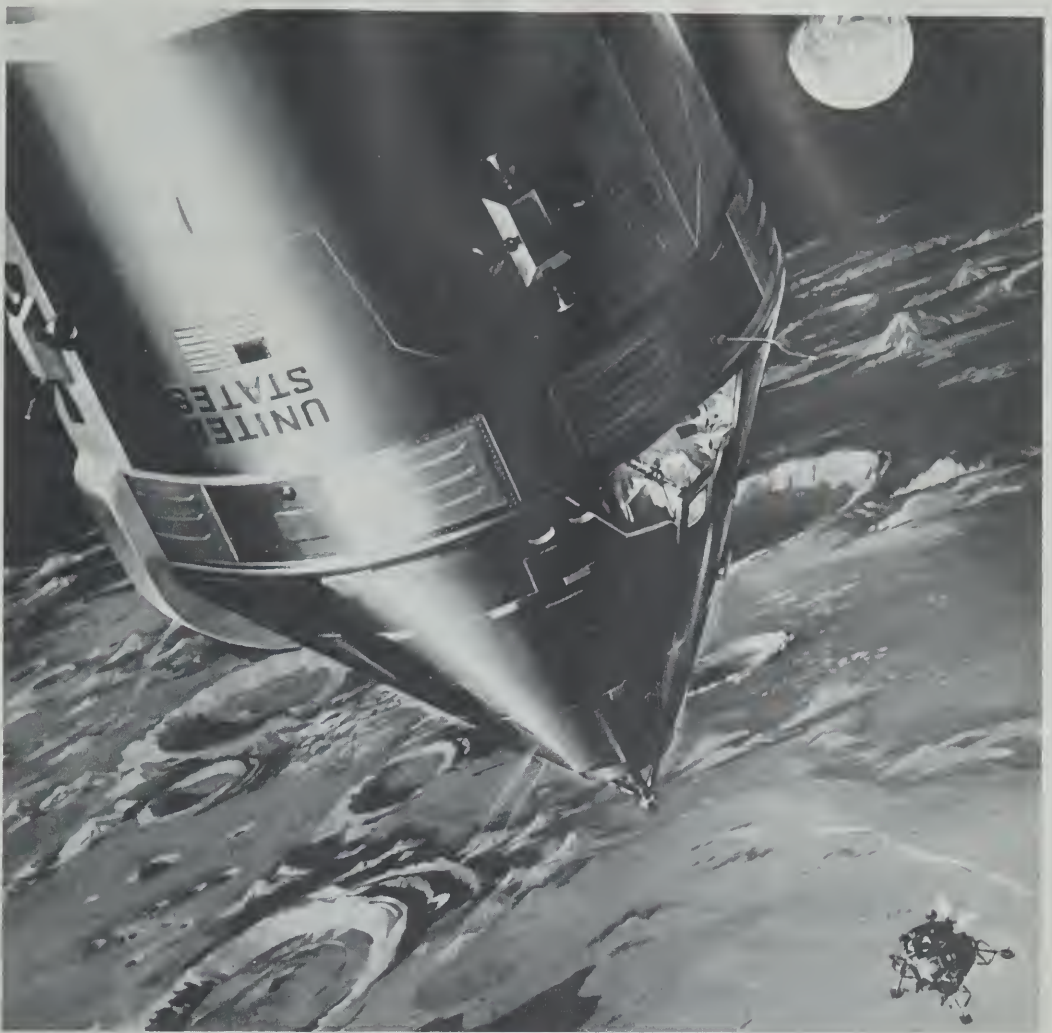
Steel Hull



Twin Screws

What answers?
Consider the what?
the why?
and the when?
Where might you be able to see the actual craft?

Man's Journey continues today and will tomorrow. Faster and safer craft are being perfected. They reduce the time required to travel great distances, equipped with instruments to determine location and speed and to make corrections in navigation. And we will never run out of men like Ptolemy, Marco Polo, Prince Henry, Columbus,Galileo, Newton, Einstein, Von Braun, Gagarin, Leonov, Neil Armstrong and Jacques Cousteau. Man is impelled to constantly navigate and explore. Who will be tomorrow's men of science and invention? Who will be tomorrow's astronauts and aquanauts?



HERE MEN FROM THE PLANET EARTH
FIRST SET FOOT UPON THE MOON
July 1969 A.D.
WE CAME IN PEACE FOR ALL MANKIND

What do the astronauts of today owe to the past?
What will the astronauts of tomorrow owe to us?

Bibliography

Books

Armstrong, Richard. *The Early Mariners.* Ernest Benn Ltd., 1967.

Andrist, Ralph K. with G. J. Dufek. *Heroes of Polar Exploration.* Horizon Caravel, 1962.

Andrist, Ralph K. and E. R. Bingham. *To the Pacific with Lewis & Clark.* Heritage, 1967.

Andrist, Ralph K. with C. B. Mitchell. *Steamboats on the Mississippi.* Heritage, 1962.

Berger. *Discoveries of the New World.* Heritage, 1960.

Brander. *The River Nile.* National Geographic Society.

Branley, Frank M. *Man in Space to the Moon.* Thomas Y. Crowell, 1970.

Brown, L. A. *The Story of Maps.* Bonanza, 1949.

Coggins. *By Star and Compass.* Dodd, Mead.

Cornwall, A. B. *Ships.* Educational Supply Association, 1961.

Cox. *America's Explorers of Space.* Hammond, 1967, 1969.

Crone, G. R. *Maps and Their Makers.* Hutchinson, 1968.

Dille. *Americans in Space.* Heritage, 1965.

Donovan. *Vikings.* Horizon Caravel, 1964.

Gibson, C. E. *The Story of the Ship.* Abelard & Schuman, 1958.

Hale, J. R. *Age of Exploration.* Time-Life.

Hammond. *Earth and Space.* 1970.

Jane, Cecil. *The Journal of Christopher Columbus.* Bramhall House, 1960.

Koenig. *The Travels of Marco Polo.* Golden, 1966.

Lord. *Peary to the Pole.* Harper & Row, 1963.

McKendrick, with Elliot. *Ferdinand and Isabella.* Horizon Caravel, 1968.

Musky. *Balboa: Discoverer of the Pacific.* Harper & Row, 1964.

Parry, J. H. *The Age of Reconnaissance.* Mentor, 1964.

Robinson, C. *The Elizabethan Ship.* Longmans, 1964.

Romola-Anderson. *The Sailing Ship.* Harrap, 1927.

Sanderlin, George. *Across the Ocean Sea.* Harper & Row, 1966.

Sanderlin, George. *Eastward to India.* Harper & Row, 1965

Sanderlin, George. *First around the World.* Harper & Row, 1964.

Shippen. *Leif Eriksson.* Harper & Row, 1951.

Sterling, with Kimble. *Exploration of Africa.* Horizon Caravel, 1963.

Taylor, E. G. R. *The Haven-Finding Art.* Hollis & Carter, 1963.

Toolby, R. V. *Maps and Map-Makers.* Bonanza, 1962.

Universal History of the World, Vol. 1. *Early Civilization.* Golden, 1960.

Universal History of the World, Vol. 8. *Reformation and Exploration.* Golden, 1960.

Verleyen, Cyriel. *The Egg of Christopher Columbus.* Thomas Y. Crowell, 1971.

Villiers. *Men, Ships and the Sea.* National Geographic Society.

Waldman. *The Voyages of Christopher Columbus.* Golden, 1966.

Warmer. *Captain Cook and the South Pacific.* Horizon Caravel, 1963.

Films

The Age of Discovery, 16 mm, 11 minutes, Coronet.

Alexander Mackenzie (The Lord of the North), 16 mm, colour, NFB.

Boats, 16 mm, 11 minutes, Encyclopedia Britannica.

Canoeing the Big Country (B.C.), 16 mm, colour, Douglas Sinclair.

The Compass, 16 mm, 11 minutes, McGraw.

David Thompson (The Great Mapmaker), 16 mm, black & white, NFB.

The Development of Transportation, 16 mm, 11 minutes, Erpi Classroom Films Inc.

Earth Satellites, Explorers of Outer Space, 16 mm, 17 minutes, Encyclopedia Britannica.

Explorations of Prince Henry, 16 mm, 15 minutes, Ontario Department of Education.

First Men in Space, Solving the Survival Problem, 16 mm, 16 minutes, Encyclopedia Britannica.

John Cabot (A Man of Renaissance), 16 mm, black & White, NFB.

The Last Voyage of Henry Hudson, 16 mm, black & White, NFB.

Latitude, Longitude and Time Zones, 16 mm, 14 minutes, Sovereign.

The Manhattan Odyssey, 16 mm, 35 mm, colour, NFB.

Marco Polo, 16 mm, 18 minutes, Encyclopedia Britannica.

Navigation — The Tools of Discovery, 16 mm, 18 minutes, Educational Film Distributors.

Northwest Passage, 16 mm, colour, NFB.

Sailing Newfoundland Waters, 16 mm, colour, Victor Kayletz Production.

Samuel de Champlain, 16 mm, colour, NFB.

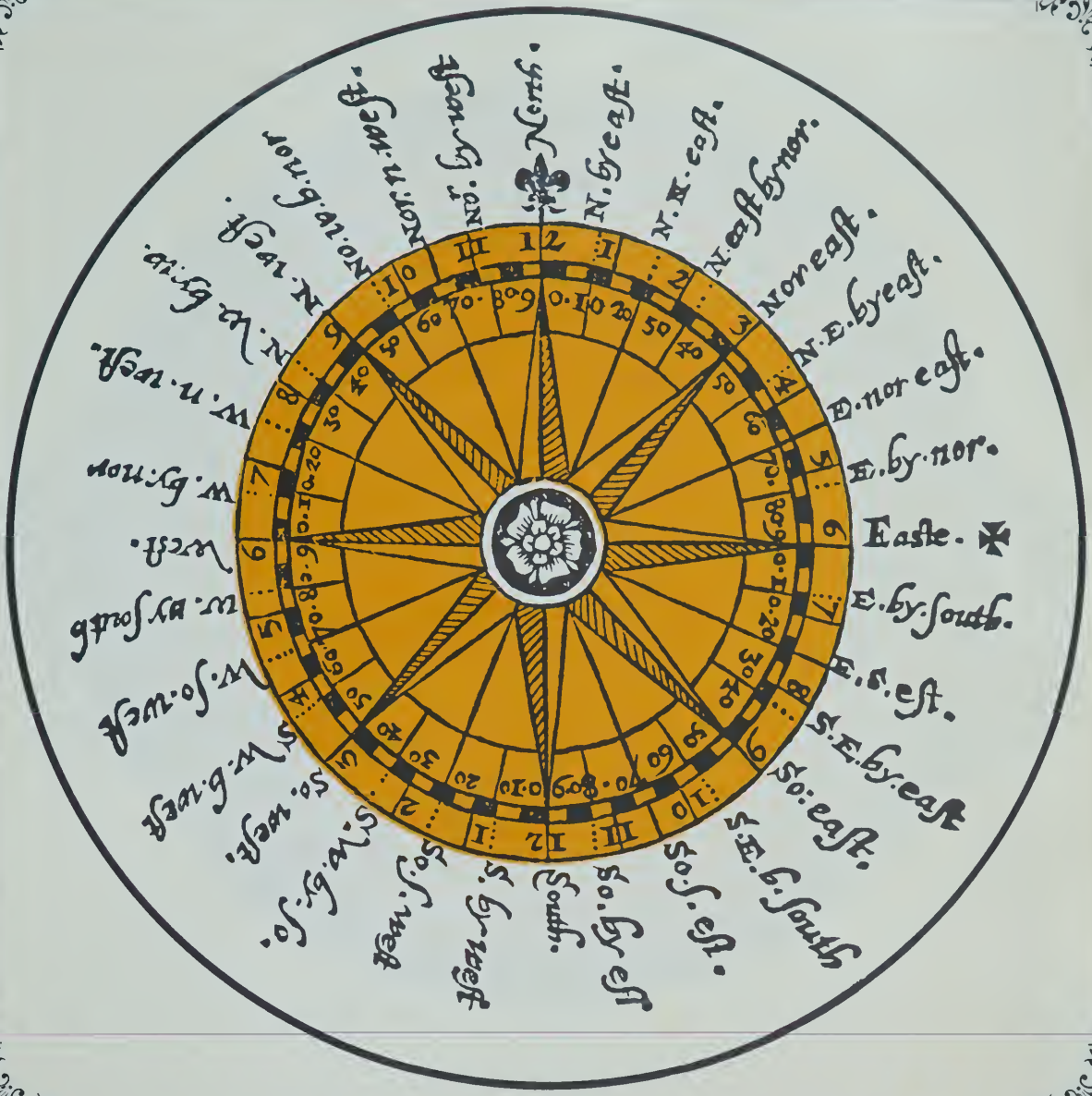
Story of Christopher Columbus, 16 mm, 17 minutes, Encyclopedia Britannica.

Time Is, 16 mm, 30 minutes, McGraw.

Trip to the Moon, 16 mm, 15 minutes, Encyclopedia Britannica.

Voyageur Country, 16 mm, colour, Crawley Films Ltd.

Which Way Is North, 16 mm, 14 minutes, Encyclopedia Britannica.



An Ancient Atlas

SUPPLEMENT TO

The Navigators

Fitzhenry & Whiteside Limited

The World According to Hecataeus

Hecataeus' drawing is typical of early Greek maps of the world. Make a list of the similarities between this map and the other maps in *An Ancient Atlas*. Describe three major ways in which they all differ from the maps found in a modern atlas. (See page 44, *The Navigators*).

The World According to Ptolemy

On the right of this map, drawn by Ptolemy in 150 A.D., the distance in degrees north and south of the equator is marked. The distance along the equator is measured across the top and bottom of the map. What do you think the figures on the left mean? (See page 45, *The Navigators*).

The Hereford World Map

This map, drawn about 1280 A.D., is shown with the East (Paradis) at the top. How should the map be turned to place the East in its normal position? Make a list of features on this map that reflect the religious thought of its maker. (See page 46, *The Navigators*).

Danger in the Northern Seas

This map is the work of Olaus Magnus, a Swedish cartographer who created it in 1539. He shows enormous monsters in the water chewing up various kinds of ships. What types of crafts are shown? What do you suppose the danger at point F might be? (See page 46, *The Navigators*).

The Map of Fra Mauro

This partial map derives from an enormous circular chart of the world drawn in 1459 by Fra Mauro. The descriptive notes he collected from talkative travellers. What features depicted on the map have proven to be fanciful and what features have proven to be factual?

(See page 48, *The Navigators*).

The World According to Toscanelli

A chart such as this was sent to Christopher Columbus by Toscanelli in 1492. Take Toscanelli's map together with all of the others in *An Ancient Atlas* and rate them in order of accuracy. Which is closest to the truth? Which is the least accurate? (See page 52, *The Navigators*).

The World According to Henricus Martellus

This outline is based on Martellus' map of 1489. (See page 50, *The Navigators*).

An Ancient Atlas, supplement to *The Navigators*

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Designer: Hugh Michaelson Ltd.
Printed and Bound in Canada

Fitzhenry & Whiteside Limited

Toronto Montreal Winnipeg Vancouver